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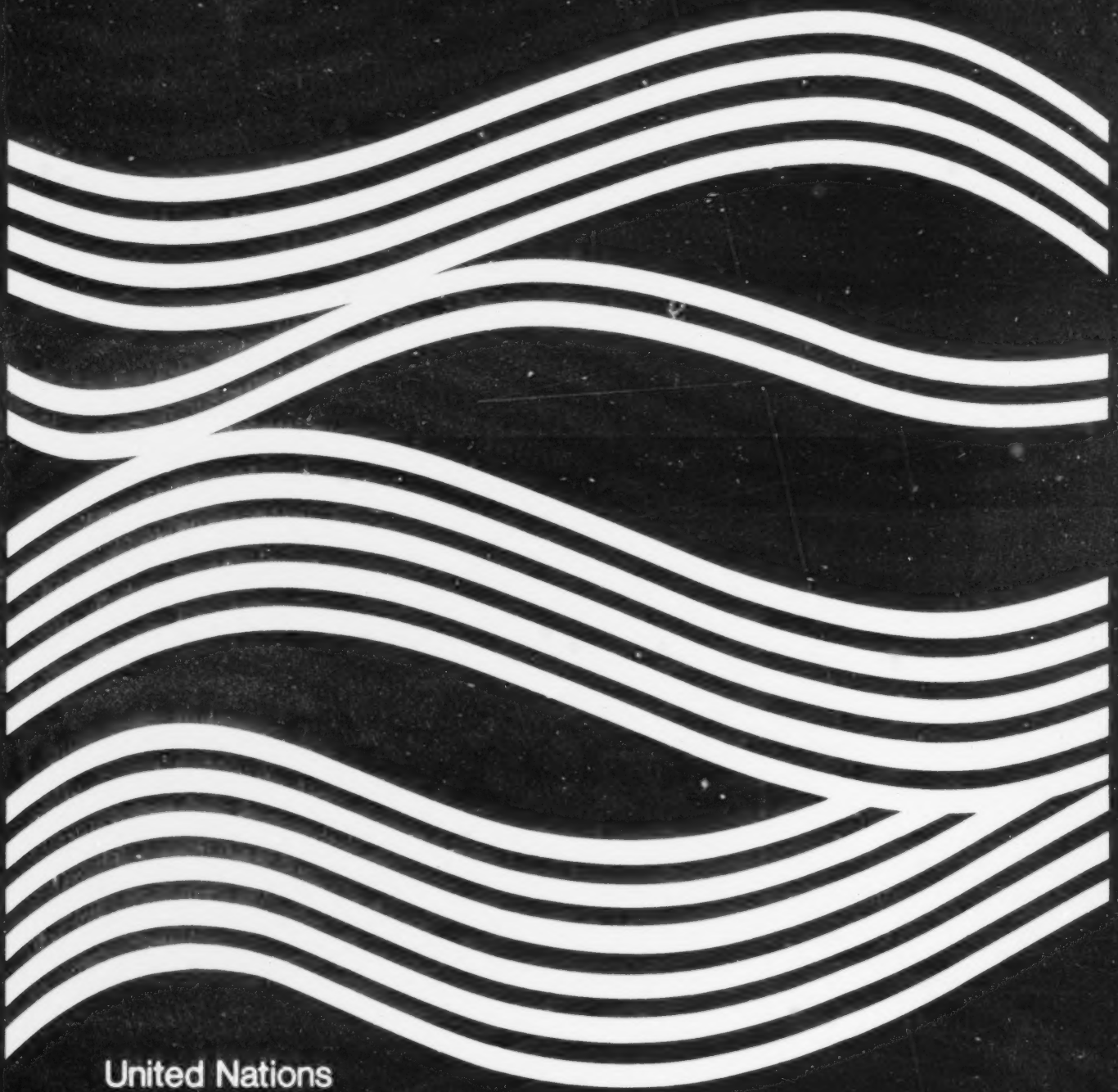

United Nations

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INTRODUCTION

1. Data on the tropical cyclones, floods and droughts which have caused major damage in various countries and areas in the ESCAP region have been published annually in the *Water Resources Journal* since 1952. The current issue reviews tropical cyclones, floods and droughts and the damage that they caused in the year 1979.

2. The first chapter gives a general resume of the tropical cyclones that developed during 1979 over the western North Pacific Ocean and the Bay of Bengal region. This is followed by a narrative of each of the major typhoons which have caused heavy damage to countries along their tracks. The third chapter gives details of the damage caused by cyclones, floods and droughts in individual countries and areas.

3. Most of the data have been supplied by the departments responsible in the countries or areas concerned and the ESCAP secretariat takes this opportunity to thank them for their co-operation. Special acknowledgement is made of the *Annual Typhoon Report, 1979* of the United States Fleet Weather Central Joint Typhoon Warning Center (JTWC), Guam, from which the tracks of typhoons and narratives of destructive individual typhoons have been reproduced in this issue.

Note

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The rates of exchange quoted in this publication are generally those of the 1979 period average to be found in International Monetary Fund, *International Financial Statistics*, April 1980.

The use of a dash (–) in a table indicates "nil" or "a negligible amount". The use or three dots (...) indicates that the information is not available.

The times given in chapter II are GMT.

I. GENERAL SUMMARY[1]

A. GENERAL CHARACTERISTICS OF WORLD WEATHER IN 1979

1. Northern hemisphere

The mean circulation at the 700-millibar (mb) level during the winter (December 1978-February 1979) was characterized by stronger than normal mid-latitude westerlies over Asia and the western Pacific, but the band of strongest westerlies was displaced well south of its normal position from the eastern Pacific to western Europe in association with a blocking structure which extended from the north-eastern Pacific across the Canadian Arctic and Greenland to the Norwegian Sea.

During spring a strong ridge at the 700-mb level built over the central Atlantic, bringing milder weather than normal over the north-eastern United States and south-eastern Canada as southerly wind components increased. A sharp trough developed over the British Isles just downstream from the Atlantic ridge, resulting in a cold and stormy spring in much of western Europe. A vigorous low over the north-central Pacific, and an amplified ridge over western Canada and Alaska were each little more than one standard deviation from the normal. The subtropical ridge was stronger than normal over most of the Pacific, but from the eastern Pacific to the central Atlantic, below-normal heights prevailed with troughs and cyclonic activity being more frequent than usual in most low-latitude areas.

During summer the subtropical ridges over both the Atlantic and the Pacific were stronger and farther north than normal. A vigorous circulation with amplified mean waves was evident at high latitudes. This was the seventh consecutive season with a stronger than normal ridge over Alaska. The combined effects of the Alaska ridge and the strong subtropical ridge over the Pacific favoured a deepened trough near the California coast, and this led to the occasional penetration inland of rain-producing upper-level disturbances. Although tropical storm activity over both the western and eastern Pacific was less than usual, the relatively strong ridge over the Atlantic favoured an active Atlantic tropical storm season and the penetration of large quantities of moist air in the United States.

The subtropical ridges remained strong and to the north of their normal positions over both the Atlantic and the Pacific during the autumn, while unusually fast westerlies prevailed at middle latitudes over both oceans. Two major hurricanes, David and Frederic, which originated over the Atlantic, and a third unnamed tropical disturbance which developed off the coast of Texas in the periphery of the circulation of Hurricane Henri were all steered into the mainland United States by the strong easterly and southerly flow on the southern and western flanks of the persistent Atlantic subtropical ridge.

The unusually fast westerlies around most of the northern hemisphere in the last month of 1979 served to limit the extent of southward intrusions of cold air from polar regions.

2. Southern hemisphere

The year 1979 commenced with an enhanced zonal circulation extending from Australia into the eastern Pacific. This was associated with a positive anomaly of geopotential height at 500 mb which extended from western Australia towards New Zealand, in combination with a band of negative anomaly skirting the Antarctic coast between 110°E and 90°W. In February, the negative anomalies continued to skirt Antarctica, with the positive anomaly over Australia moving south-west to cover the south of the Great Australian Bight. Stronger than normal zonal flow also covered the western Indian Ocean.

The Pacific trough, which had been a marked feature late in 1978, was weak early in 1979. However, it become re-established in February and oscillated between 80°W and 140°W until September, when a positive anomaly become evident over the south-eastern Pacific. Late in the year, the trough regenerated and progressed from 130°W to 95°W. The Pacific trough was at its strongest in March and April in the sector 120°W to 100°W.

Another persistent feature was the ridge which appeared in the South Atlantic early in the year, and a southward connexion with the Pole. It was associated with blocking to the east of South America, and persisted until March, when the anomaly reached its peak. In April and May, it retrogressed and moved southward, but by mid-year it had moved north again to cover southern Argentina and Chile, where a weakening occurred.

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[1] From material to be published in World Meteorological Organization, *Bulletin*, vol. XXIX, No. 3, July 1980. Much of the information is based on material supplied by the meteorological services of the United States of American and Australia.

In March, a positive anomaly extended from southern Africa to the Australian interior. It relaxed in April to leave a weak negative anomaly over the central Indian Ocean, flanked by positive anomalies over southern Africa and the south-west of the Bight. However, by May the positive anomaly was re-established and extended from southern Africa to the seas south of Australia, with the negative anomaly in the central Indian Ocean moving south. During most of the winter months, the eastern hemisphere showed positive anomaly centres south-east of southern Africa, over the eastern Indian Ocean and across Australia to New Zealand. During August, however, the situation over New Zealand changed dramatically with the advent of a blocking pattern, such that negative anomalies appeared over New Zealand.

The weak negative anomaly apparent in May over the central Indian Ocean deepened in June. It then spread from 10°E to 130°E and remained until September, when it split in two.

In October, the positive anomaly over the eastern Indian Ocean moved east over south-western Australia, linking with a ridge in the Tasman Sea. By November, it extended from south-eastern Australia to the south-western Pacific with a centre over New Zealand. Negative anomalies showed up over a large proportion of the Antarctic coast, although positive anomalies continued over Antarctica itself from August to the end of the year.

The trough evident west of Australia in November collapsed, to be replaced by a ridge in December which covered most of the eastern hemisphere in a latitude band 30°S to 40°S. A negative anomaly band extended from 50°E to 170°E with centres near Kerguelen and to the south of Tasmania. The band covered the zone between 40°S and 60°S and gave rise to strong zonality over a large part of the Indian Ocean and over most of southern Australia.

B. SUMMARY OF TROPICAL CYCLONES[2]

1. Western North Pacific

During 1979, the western North Pacific experienced a below-normal year of tropical cyclone activity with a total of 28 cyclones (table 1). By comparison, 1978 was a near-normal year with 32 cyclones and 1977 was a near record low year with a total of 21 cyclones. Five significant tropical cyclones never developed beyond tropical depression (TD) stage, and nine developed into tropical storms (TS). Of the 14 cyclones that developed to typhoon (TY) stage only 4 reached the 130 kt (67 m/sec) intensity necessary to be classified as a super typhoon (ST). In 1979, beginning with Typhoon Bess, tropical cyclones attaining tropical storm strength or greater were assigned names on an alternating male/female basis. Each tropical cyclone's maximum surface wind, in knots, and minimum observed sea-level pressure, in millibars, were obtained from best estimates of all available data. The distance travelled, in nautical miles (nm), was calculated from the Joint Typhoon Warning Centre (JTWC) official best track.

Table 2 provides further information on the monthly distribution of tropical cyclones and statistics on Tropical Cyclone Formation Alerts and Warnings. Even though there were four fewer cyclones during the 1979 season than during the 1978 season, there were 18 more warning days.

2. North Indian Ocean

During 1979, seven significant tropical cyclones occurred in the North Indian Ocean area (table 1). As usual, the transition seasons between the north-east and south-west monsoon periods were the favoured "cyclone seasons" (table 3). This was an above-normal season with most activity occurring during the full transition period.

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[2] United States Fleet Weather Central Joint Typhoon Warning Center, *Annual Typhoon Report, 1979* (Guam, Mariana Islands, 1980).

Table 1. Tropical cyclones, 1979

Cyclone	Type[a]	Name	Period of warning	Calendar days of warning	Maximum surface wind (knots)	Minimum observed sea level pressure (millibars)	Number of warnings	Distance travelled (nautical miles)
			Western North Pacific					
01	TY	Alice	01 Jan.-14 Jan.	14	110	930	51	2,597
02	TY	Bess	20 Mar.-25 Mar.	6	90	958	21	1,804
03	TY	Cecil	11 Apr.-20 Apr.	10	80	965	40	2,535
04	TS	Dot	10 May-16 May	7	40	984	24	2,876
05	TD	TD-05	23 May-24 May	2	30	998	6	2,170
06	TY	Ellis	01 July-06 July	6	85	955	22	1,612
07	TS	Faye	01 July-06 July	6	40	998	20	1,837
08	TD	TD-08	24 July-25 July	2	20	1,004	5	1,264
09	ST	Hope	27 July-03 Aug.	10	130	898	33	3,928
10	TS	Gordon	26 July-29 July	4	60	980	13	1,058
11	TD	TD-11	03 Aug.-06 Aug.	4	25	997	14	1,088
12	TY	Irving	09 Aug.-18 Aug.	10	90	954	38	2,732
13	ST	Judy	16 Aug.-26 Aug.	11	135	887	39	2,502
14	TD	TD-14	18 Aug.-20 Aug.	3	20	1,006	9	605
15	TS	Ken	01 Sept.-04 Sept.	5	60	985	13	1,418
16	TY	Lola	02 Sept.-08 Sept.	7	90	950	23	1,298
17	TY	Mac	15 Sept.-24 Sept.	10	70	984	35	1,831
18	TS	Nancy	19 Sept.-22 Sept.	4	45	993	14	528
19	TY	Owen	22 Sept.-01 Oct.	10	110	918	37	2,151
20	TS	Pamela	25 Sept.-25 Sept.	3	45	1,002	6	984
21	TS	Roger	03 Oct.-07 Oct.	6	45	985	16	1,920
22	TY	Sarah	04 Oct.-15 Oct.	12	110	929	43	1,194
23	ST	Tip	05 Oct.-19 Oct.	16	165	870	60	3,972
24	ST	Vera	02 Nov.-07 Nov.	6	140	915	23	1,868
25	TS	Wayne	08 Nov.-13 Nov.	6	50	990	22	1,559
26	TD	TD-26	01 Dec.-02 Dec.	2	30	998	6	1,070
27	TY	Abby	01 Dec.-14 Dec.	14	110	951	52	4,044
28	TS	Ben	21 Dec.-23 Dec.	3	60	990	10	2,245
			Total	149[b]			695	
			North Indian Ocean					
	TC	17-79	06 May-12 May	7	85	967	26	1,267
	TC	18-79	18 June-20 June	3	50	985	12	581
	TC	22-79	21 Sept.-23 Sept.	3	25	1,000	10	694
	TC	23-79	21 Sept.-25 Sept.	5	55	980	14	1,108
	TC	24-79	29 Oct.-01 Nov.	4	35	995	13	720
	TC	25-79	16 Nov.-17 Nov.	2	40	994	8	547
	TC	26-79	23 Nov.-25 Nov.	3	30	995	10	1,071
			Total	24[b]			93	

Source: United States Fleet Weather Central Joint Typhoon Warning Center, *Annual Typhoon Report, 1979* (Guam, Mariana Islands, 1980).

[a] TD = tropical depression; TS = tropical storm; TY = typhoon; TC = tropical cyclone; ST = super typhoon.

[b] Overlapping days included only once in sum.

Table 2. Significant tropical cyclone statistics in the western North Pacific Ocean, 1979

	Jan.	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Total*	*Average (1959-1978)*
Tropical depressions	0	0	0	0	1	0	1	2	0	0	0	1	5	4.8
Tropical storms	0	0	0	0	1	0	2	0	4	1	1	1	10	10.0
Typhoons	1	0	1	1	0	0	2	2	2	2	1	1	13	18.0
All cyclones	1	0	1	1	2	0	5	4	6	3	2	3	28	32.8
Average (1959-1978)	0.6	0.4	0.6	0.9	1.4	2.1	5.2	6.8	6.0	4.8	2.7	1.3	32.8	

Formation Alerts: 23 of the 27 (85 per cent) Formation Alert Events developed into tropical cyclones.

5 of the 28 (18 per cent) tropical cyclones did not have a Formation Alert.

Warnings: Number of warning days: 149.

Number of warning days with two cyclones: 38.

Number of warning days with three or more cyclones: 5.

Source: Same as table 1.

Table 3. Significant tropical cyclone statistics in the North Indian Ocean, 1979

	Jan.	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Total*
All cyclones	0	0	0	0	1	1	3	0	2	1	2	0	7
Average[a] (1971-1978)	0.1	0	0	0.3	0.5	0.3	0	0	0.4	0.8	1.4	0.3	4

Formation Alerts: 7 of the 8 (87 per cent) Formation Alert Events developed into numbered cyclones.

Warnings: Number of warning days: 25.

Number of warning days with two cyclones: 3.

Number of warning days with three or more cyclones: 0.

Source: Same as table 1.

[a] From 1971 through 1974, only Bay of Bengal cyclones were considered; the JTWC area of responsibility was extended in 1975 to include Arabian Sea cyclones.

Table 4. Natural disasters, 1979 (Current prices)

Country or area	Nature of disaster	Area affected (ha)	Population affected (number)	Casualties		Houses or buildings (number)		Damage to crops and cultivated land	Livestock lost (head)	Damage to private property and public utilities ($US million)	Subtotal ($US million)	Total estimated damage ($US million)
				Dead or missing	Injured	Destroyed	Damaged					
Australia	Cyclone			15				Approximately $US 3 million		33-37.00	38.00	62.61
	Flood									2.24	2.24	
	Storms				23	53	350			22.37	22.37	
Burma	Flood	160,623								1.68	1.68	3.30
	Drought	1,411,996										
	Cyclone										1.62	
Hong Kong	Typhoons		15,709	16	327	53		1,450 ha of veg; 84,500 fruit trees; 50 ha of fish ponds	113,000	3.57		3.57
India	Floods	3,962,000	18,314,000	3,634			1,319,124 houses; $US 257.56 million	2,111,000 ha; $US 177.55 million	619,000	299.56		734.67
Indonesia	Floods, etc.	31,000		1,154	1,086		12,000		639			28.53
Japan	Typhoons			125	561	130	51,539	40,588 ha			1,409.12	2,015.48
	Storms			33	73	79	48,039	33,767 ha			606.36	
Malaysia:												
West Malaysia	Flood		53,394; 131 villages	10		8	455	$US 140,402		0.94	1.09	
	Drought		20,000					$US 40,512			0.04	
East Malaysia	Storms		538					405 ha		0.46	0.46	1.59
	Drought		2,000									
New Zealand	Flood									1.01		1.01
Philippines	Storms									0.38		56.16
	Typhoons			137	73					55.78		
Republic of Korea	Storms	84,465		237	51	1,323	2,585; $US 6.76 m	112,673 tons; $US 73.56 m; 4,470 ha; $US 11.61 m		61.19	153.12	373.05
	Typhoons	53,621		153	95	1,544	11,579; $US 4.89 m	107,355 tons; $US 82.16 m; 3,244 ha; $US 9.69 m		123.19	219.93	
Thailand	Drought							420,421 ha				
	Flood			42	6	360	3,334	60,351 ha	354	2.55		2.55
Viet Nam	Flood		260,000					64,000 ha				

Source: Meteorological services of the countries concerned. See chapter III.

Note: Exchange rates are 1979 period averages from International Monetary Fund, *International Financial Statistics*, April 1980.

Table 5. Damage caused annually by tropical cyclones, heavy rains and floods in selected countries and areas in the ESCAP region, 1965-1979

($US million, 1975 prices)[a]

Country or area	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*	*1977*	*1978*	*1979*	*Total*	*Annual average*[b]
Australia	0.4	0.4	28.4	0.3	0.4	9.2	435.9	–	6.9	415.9	26.2	102.1	2 4	61.9	41.7	1,132.1	75.5
Bangladesh	274.2	201.8	...	565.1	254.9	1,129.1	357.6	106.8	266.3	380.1	11.4	...	13.5[c]	...	...	3,560.8	323.7
Burma	...	20.4	4.1	27.9	18.5	14.7	31.8	4.2	58.2	61.1	129.2	76.3	1.0[c]	1.0[c]	2.8[c]	451.2	32.2[c]
Hong Kong	...	8.8	...	0.2	0.1	0.5	1.8	14.4	1.4	0.9	0.6	...	...	1.9[c]	3.6[c]	34.2	3.1[c]
India	23.6	182.2	334.0	533.0	803.8	681.7	1,266.4	278.0	877.6	720.0	562.6	1,180.8	1,294.0	1,267.3	674.0	10,679.0	711.9
Japan	1,547.0	1,370.9	1,300.7	577.0	1,024.5	791.0	1,510.7	3,010.6	495.5	1,946.0	1,985.9	2,656.0	...	...	1,587.0	19,802.8	1,523.3
Lao PDR[d]	...	16.1	...	2.7	...	0.6	3.5	0.1	3.0	...	...	...	...	...	...	26.0	4.3
Malaysia	9.4	–	21.0	0.4	1.3	10.3	...	0.4	0.5	1.8	1.9	0.8	0.4	2.2	1.4	51.8	3.7
New Zealand	2.8	2.2	2.3	10.2	1.0	4.0	...	1.1	2.9	...	27.1	31.2	...	13.6	0.6	99.0	8.3
Philippines	0.9	16.0	0.3	7.5	0.9	261.9	11.0	227.1	9.9	67.2	9.2	79.7	235.0	171.4	38.4	1,136.4	75.8
Republic of Korea	64.4	31.9	2.2	25.1	130.1	86.5	40.7	113.5	15.4	18.8	15.6	23.1	87.7	38.2	217.0	910.2	60.7
Sri Lanka	...	...	0.6	...	...	...	...	...	...	...	0.1	...	...	87.9	...	88.6	29.5
Thailand	1.5	50.0	12.9	11.9	49.7	77.2	7.2	13.5	12.0	18.6	51.6	5.2	6.8	168.5	1.9	488 5	32.5
Viet Nam	8.2	44.4	–	0.4	0.1	7.2	...	...	12.6	...	...	...	135.0[c]	...	...	207.9	26.0
	1,932.4	1,945.1	1,706.5	1,761.7	2,285.3	3,073.9	3,666.6	3,769.7	1,762.2	3,630.4	2,821.4	4,155.2	1,775.8	1,813.9	2,568.4	38,668.5	2,910.5

[a] Value for 1965 to 1975 in 1975 prices calculated using the consumer price index (United Nations, Statistical Yearbook, 1974 and Monthly Bulletin of Statistics, 1976) and converted to United States dollars using Official Exchange Rate Special Average (International Monetary Fund, *International Financial Statistics*, May 1976). For 1976 and 1977, both calculations based on *International Financial Statistics*, May 1978. Calculations for 1978 based on *International Financial Statistics*, April 1979 and for 1979 based on *International Financial Statistics*, April 1980.

[b] Annual average is the total of annual averages of all the countries.

[c] Current prices.

[d] 1974 prices.

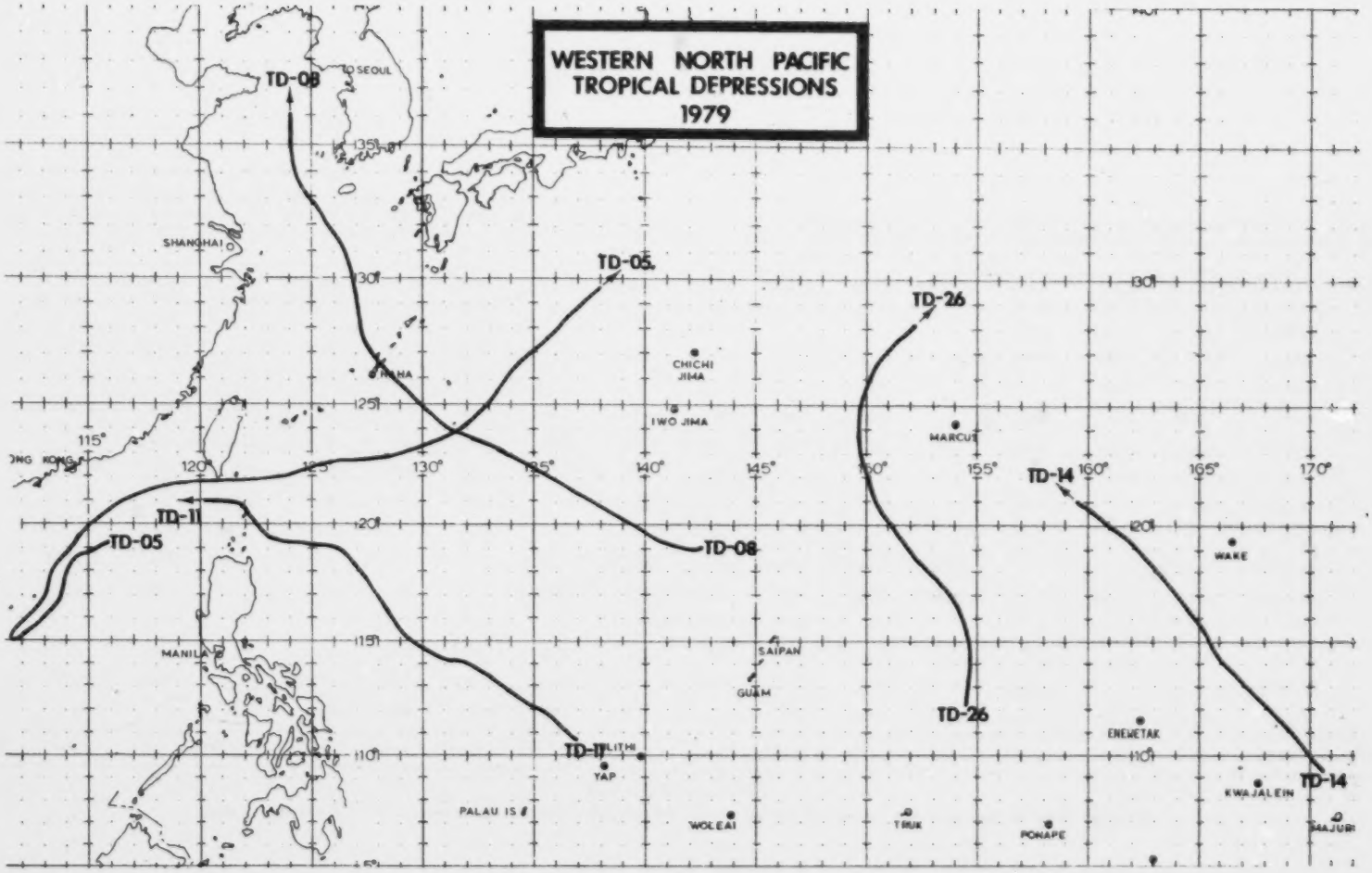


Figure 1. Western North Pacific tropical depressions, 1979

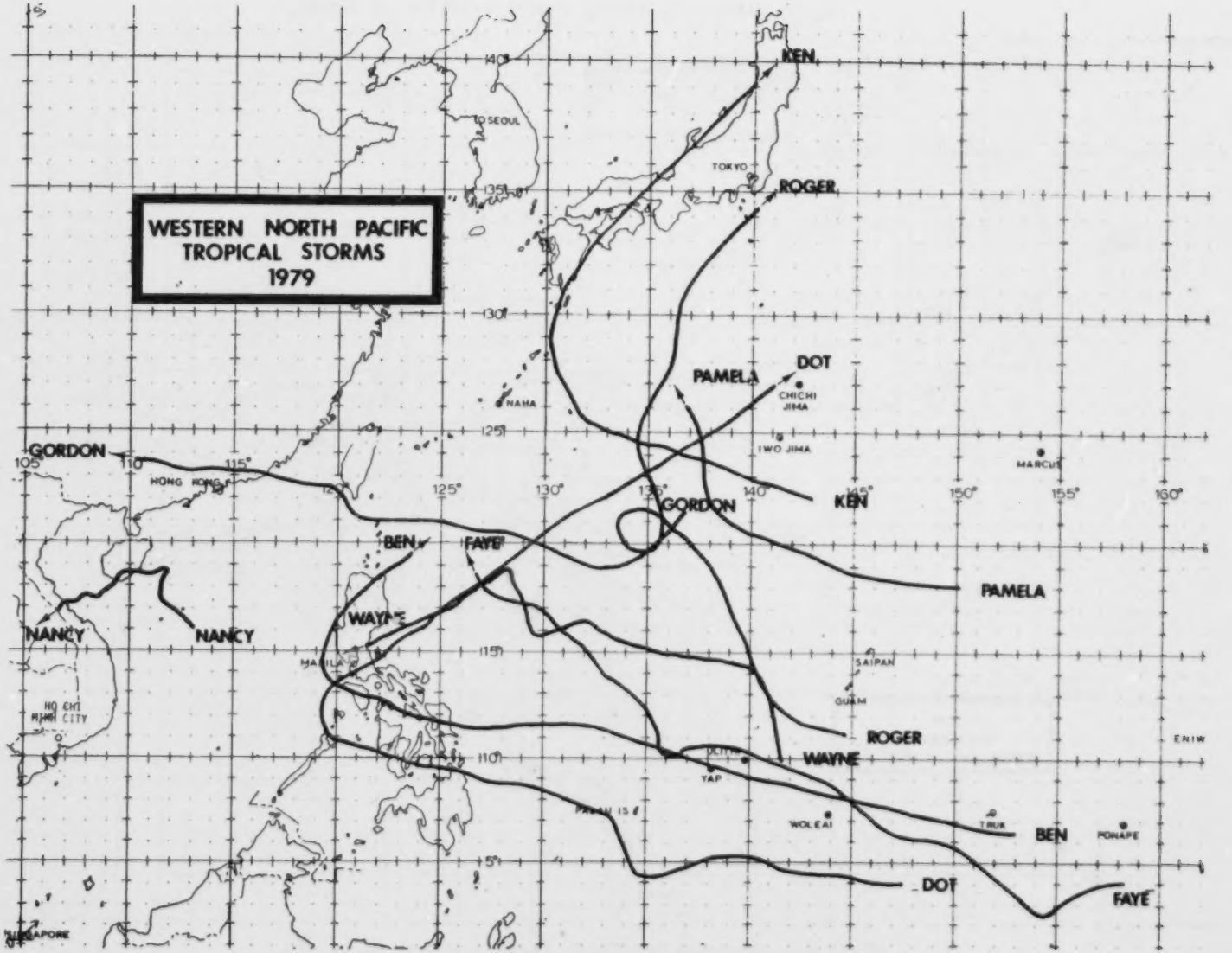


Figure 2. Western North Pacific tropical storms, 1979

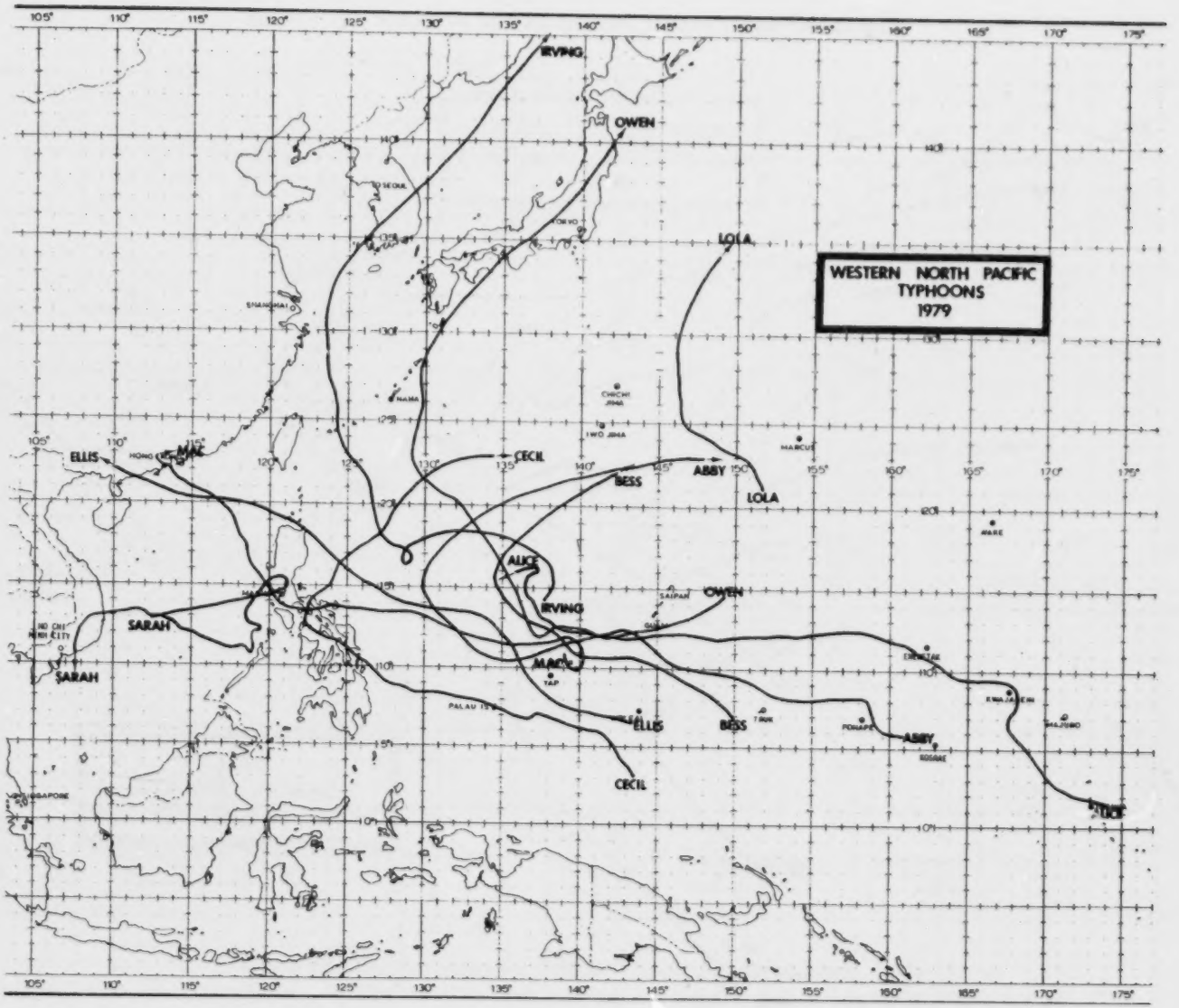


Figure 3. Western North Pacific typhoons, 1979

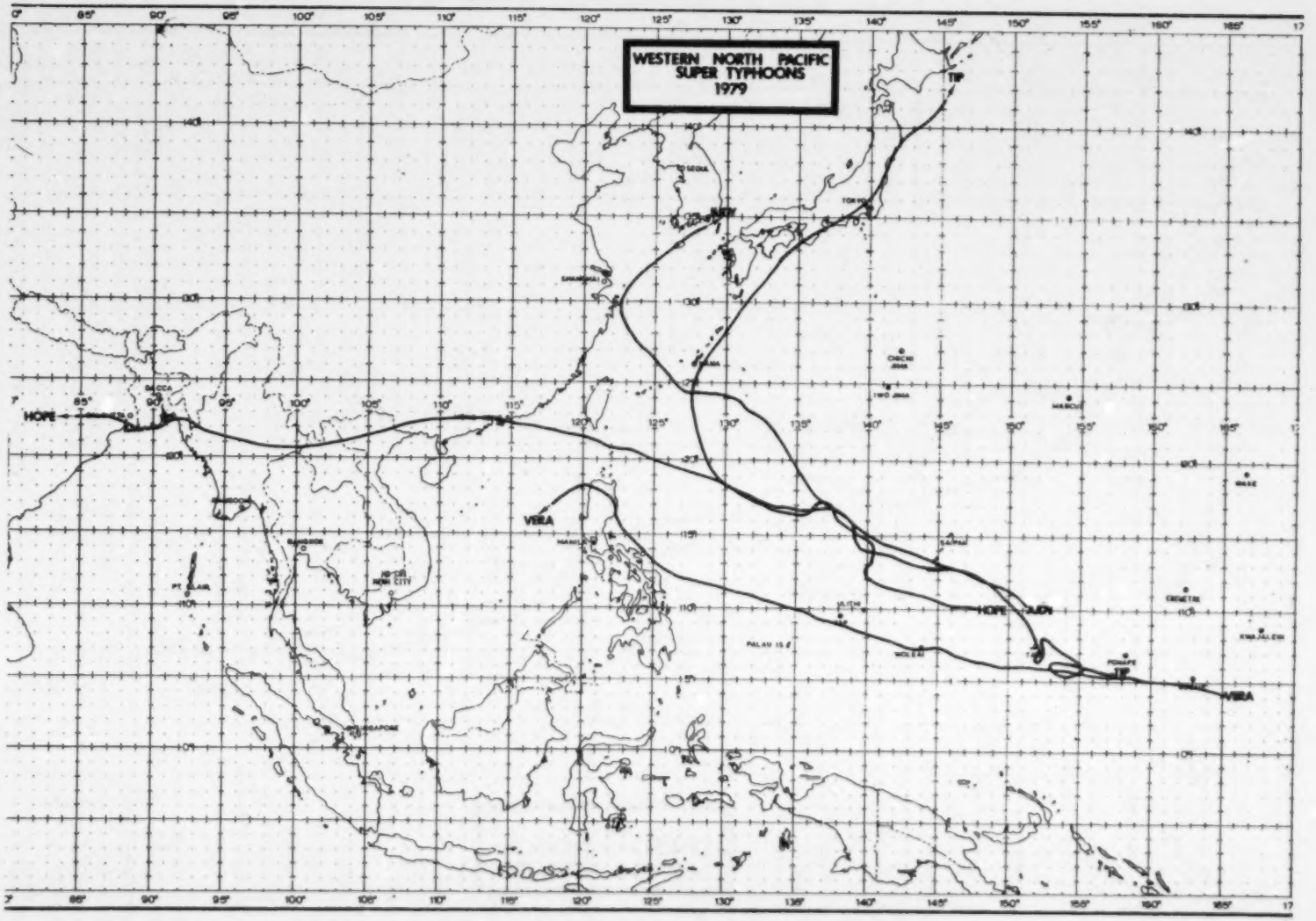


Figure 4. Western North Pacific super typhoons, 1979

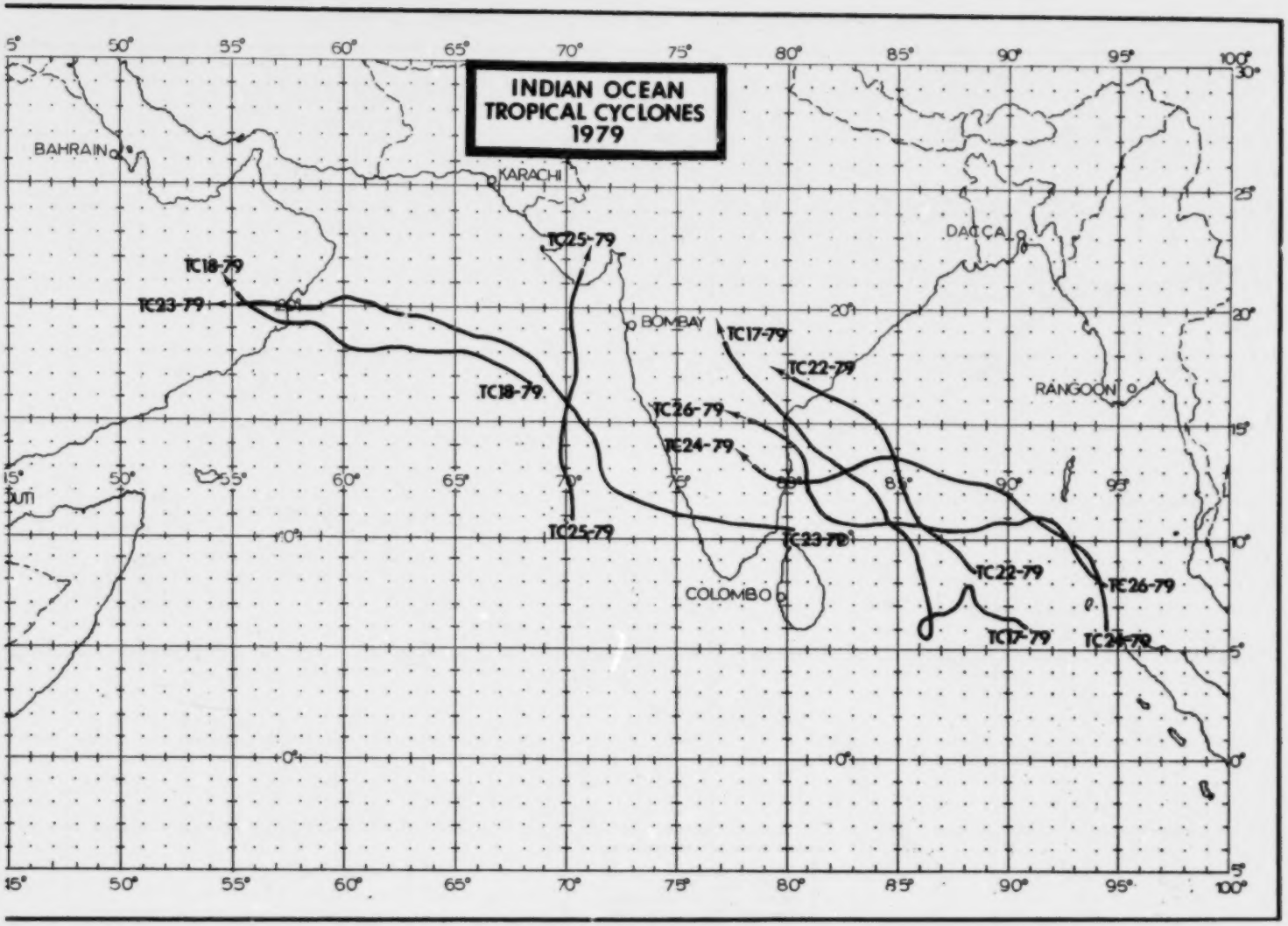


Figure 5. Indian Ocean tropical cyclones, 1979

II. INDIVIDUAL NARRATIVES OF MAJOR TYPHOONS[3]

A. TYPHOON ALICE

Typhoon Alice, the first tropical cyclone of the 1979 season, was actually first sighted as a tropical disturbance on 27 December 1978. Located over the Gilbert Islands (now Kiribati) quite close to the equator, the potential for development was considered poor. A tropical cyclone formation alert was issued at 0300 hours on 1 January 1979, when satellite data showed the disturbance progressively increasing in organization. Soon after, the suspect area accelerated north-west to higher latitudes where development conditions were more favourable, and by 1800 hours on 1 January, tropical storm Alice was named. Post-analysis showed that the tropical depression stage began as early as midnight at low latitudes, contrary to the general rule that cyclones do not form close to the equator.

Although it was a climatologically-unfavoured period for western North Pacific tropical cyclone development, the fact that Alice formed supports the non-existence of a definitive "typhoon season" for the western Pacific; tropical cyclones are possible any time of the year. The greatest forecasting difficulties and concomitant large forecast errors occurred during Alice's formative and dissipating stages. Double intensification also contributed to Alice's notoriety.

Early in her lifetime, Alice meandered through the Marshall Islands as if determined to visit each island (see figure 6). One week later, on 12 January 1979, the Marshall Islands were declared a major disaster area.

A satellite reconnaissance fix at 2133 on 2 January showed Alice had moved north-eastward when forecast to continue north-westward. Being a fix on a poorly defined satellite image, it was not accepted; north-west movement continued to be forecast. An aircraft reconnaissance fix at 0053 on 3 January confirmed the earlier satellite fix, as did a follow-up at 0310. Post-analysis revealed that a mid-latitude, short-wave trough passed north of Alice during this time period. The trough extended deep enough into the tropics to weaken the mid-tropospheric ridge. This weakness permitted a southward intrusion of mid-latitude westerlies into Alice's vicinity, temporarily steering her north-eastward. As the short-wave trough continued eastward, the subtropical ridge quickly re-established itself north of Alice, producing a strong easterly steering flow, temporarily accelerating her from 4 to 10 kt (8 to 19 kilometres per hour or km/h) toward the north-west, while continued north-easterly movement was forecast. During this time, decision makers on Enewetak (also within the Marshall Islands), noting the low forecast confidence stated on prognostic reasoning messages, fortunately kept in a condition of readiness.

From 6 to 11 January, Alice travelled due west. On 8 January, Alice's intensity attained 110 kt (57 m/sec) and its speed simultaneously accelerated to 14 kt (26 km/h), the fastest observed along the track, whereupon she began weakening slowly.

On 9 January, Alice began an unexpected northward movement trend and showed further weakening. Post-analysis of low-level synoptic data and satellite imagery indicated that an approaching frontal shear-line was the responsible agent. The shear-line began interacting with Alice while she was south-east of Guam. As Alice neared Guam, radar data from Andersen Air Force Base and aircraft data indicated that Alice's previously well-defined wall cloud became larger and somewhat less organized. Cooler, drier air north of the shear-line was likely responsible for this weakening trend. A weakness in the subtropical ridge vertically above the shear-line apparently allowed for Alice's northward deviation.

The most unusual portion of Alice's track occurred during the final three days of Alice's life. The subtropical ridge was expected to persist and maintain Alice in the easterlies. As a result, the JTWC forecasts (supported by the majority of objective forecast aids) indicated westward movement until 0000 on 12 January, 18 hours after Alice had actually begun tracking north-westward. The subtropical ridge weakened in response to a long-wave trough deepening over eastern Asia. Easterly steering currents in Alice's vicinity diminished and veered in direction, permitting a more northward track. Alice reached a secondary intensity maximum of 100 kt (51 m/sec) during this period owing to her slowing in speed of movement, the increased absolute vorticity of higher latitudes and good outflow aloft.

By 13 January, Alice turned north-eastward and began weakening rapidly. The subtropical ridge was now completely severed and upper-air westerlies were shearing Alice significantly in the vertical. Close proximity of yet another frontal shear-line contributed to further weakening. The biggest suprise, however, came when Alice's low-level circulation turned almost

[3] United States Fleet Weather Central Joint Typhoon Warning Center, *Annual Typhoon Report, 1979* (Guam, Mariana Islands, 1980).

180 degrees back toward the west at about 1200 on 13 January under the influence of strong, low-level easterlies and weakened rapidly in the strong, vertical-shear environment. As a result of vertical decoupling, Alice as a shallow depression dissipated during the following 12-hour period.

B. TYPHOON CECIL

Typhoon Cecil was generated in mid-April from an easterly wave over the Philippine Sea. Cecil was forecast very well while on a climatological WNW track towards the central Philippines. Over-all, post-analysis statistics showed that mean forecast errors were better than long-term averages. Nevertheless, JTWC warnings failed to forecast the crucial recurvature point in Cecil's track (see figure 7).

Post-analysis showed that recurvature occurred 36 hours after the 1200 best track position on 15 April. Satellite imagery located Cecil just south of Samar Island in the Philippines. At this time, the 500 mb subtropical ridge axis was at 17°N with a small high-pressure cell located over Northern Luzon. Steering techniques indicated westward movement for 72 hours. Analog techniques indicated WNW movement. As a matter of fact, no objective forecast technique indicated recurvature prior to entrance into the South China Sea. The climatological average location of the 500 mb ridge axis is along 15°N for April over the Philippines and the climatological recurvature point is 15-17°N. Both synoptic and climatological data indicated a WNW track over the Philippines with recurvature late in the forecast period in the South China Sea, as Cecil tracked to the vicinity of 15°N. Post-analysis, however, revealed that the ridge axis east of the Philippines abruptly shifted south between 1200 and midnight on 16 April, with westerly winds intruding far to the south over the South China Sea. This pattern shift caused Cecil to recurve much earlier than anticipated. Within 48 hours, Cecil was well east of Luzon. The ridge axis shift was the vital piece of information not present in any of the available prognostic tools. Thus, it appears even in post-analysis that forecasting of Cecil's recurvature 36 hours in advance was beyond state-of-the-art capabilities.

C. TYPHOON ELLIS

The tropical disturbance, which later became Typhoon Ellis, was first noted on satellite and synoptic data on 25 June. The surface/gradient-level analysis showed that a broad monsoon trough had developed between Guam and the Philippine Islands. At upper levels, a tropical upper tropospheric trough (TUTT) was oriented NE-SW between the Volcano Islands and the central Philippine Islands. This TUTT allowed excellent upper-level outflow to the north-east and was expected to induce intensification of the tropical disturbance south-east of the TUTT axis. Therefore, a Tropical Cyclone Formation Alert (TCFA) was issued for the area valid at 0000 hours on 27 June.

The area was closely monitored, and when satellite imagery showed increased convective development and surface data showed decreasing pressures and increasing winds, a second TCFA was issued valid at 0600 on 30 June. Subsequent aircraft investigation revealed a minimum sea-level pressure of 1,000 mb and surface winds in excess of 35 kt (18 m/sec). On the basis of this new information, the first warning on TS Ellis was issued at 0000 on 1 July. Ellis was in a favourable position at that time, and steady intensification occurred over the next two days.

For his entire lifetime, Ellis followed an uncomplicated, classic WNW track at near climatological speeds ranging from 9-14 kt (17-26 km/h) (see figure 8). Post-analysis indicates that Ellis was moving under the influence of the ESE steering flow on the southern edge of the subtropical mid-tropospheric ridge. Ellis' nearly straight track was a result primarily of the fact that this ridge did not change in intensity or orientation during the period.

Ellis reached typhoon strength at 1200 on 2 July and a maximum intensity of 85 kt (44 m/sec) at 0000 on 3 July. Continued intensification was anticipated, but a slow weakening trend was actually observed. This weakening was associated with a drastic change in the upper-level flow pattern.

During Ellis' developing stage, the TUTT was located to the NNW and was providing the necessary outflow channel to the north-east. By 0000 on 2 July, however, an upper-level anticyclone over central China began to ridge eastward, forcing the TUTT to the north-east. Strong upper-level north-easterly winds associated with this anticyclone began to exert pressure on Ellis, shearing the convective activity to the south-west. Continuing WNW in this shearing environment, Ellis weakened steadily. By the time he was in the South China Sea, Ellis had weakened to tropical storm strength and was a completely exposed low-level circulation.

With winds of 54 kt (26 m/sec), Ellis made landfall on the Chinese coast at 0000 on 6 July, 164 nm (296 km) south-west of Hong Kong and dissipated rapidly over land thereafter.

D. SUPER TYPHOON HOPE

The disturbance which eventually developed into the first super typhoon of 1979 became evident on satellite imagery at 0000 on 25 July as a focal point of cumulus banding. Future intensification was indicated as the disturbance was situated within an area of strong upper-level diffluence associated with the southern periphery of an east-west oriented TUTT. This outflow mechanism aloft, combined with an

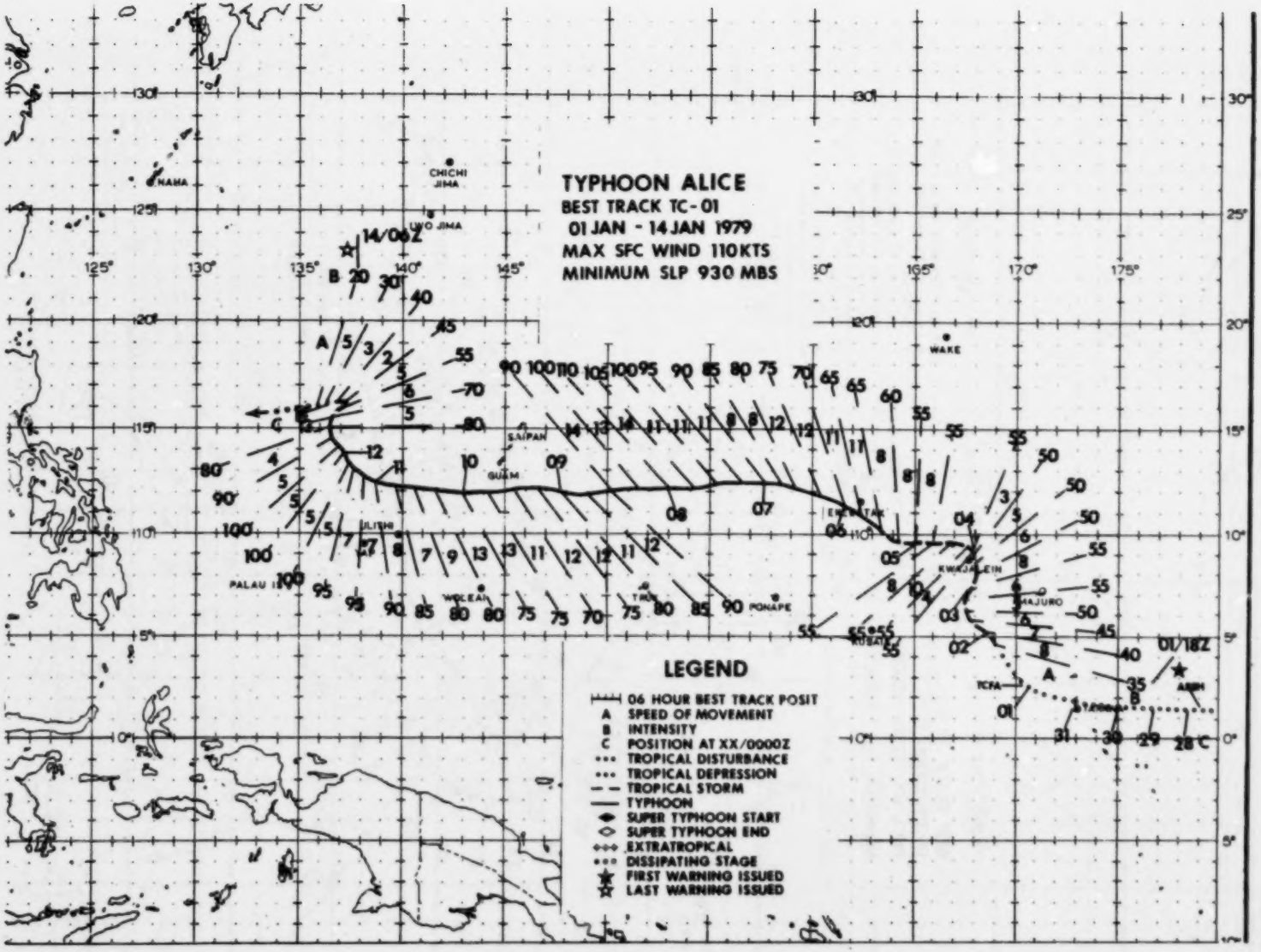


Figure 6. Typhoon Alice, best track

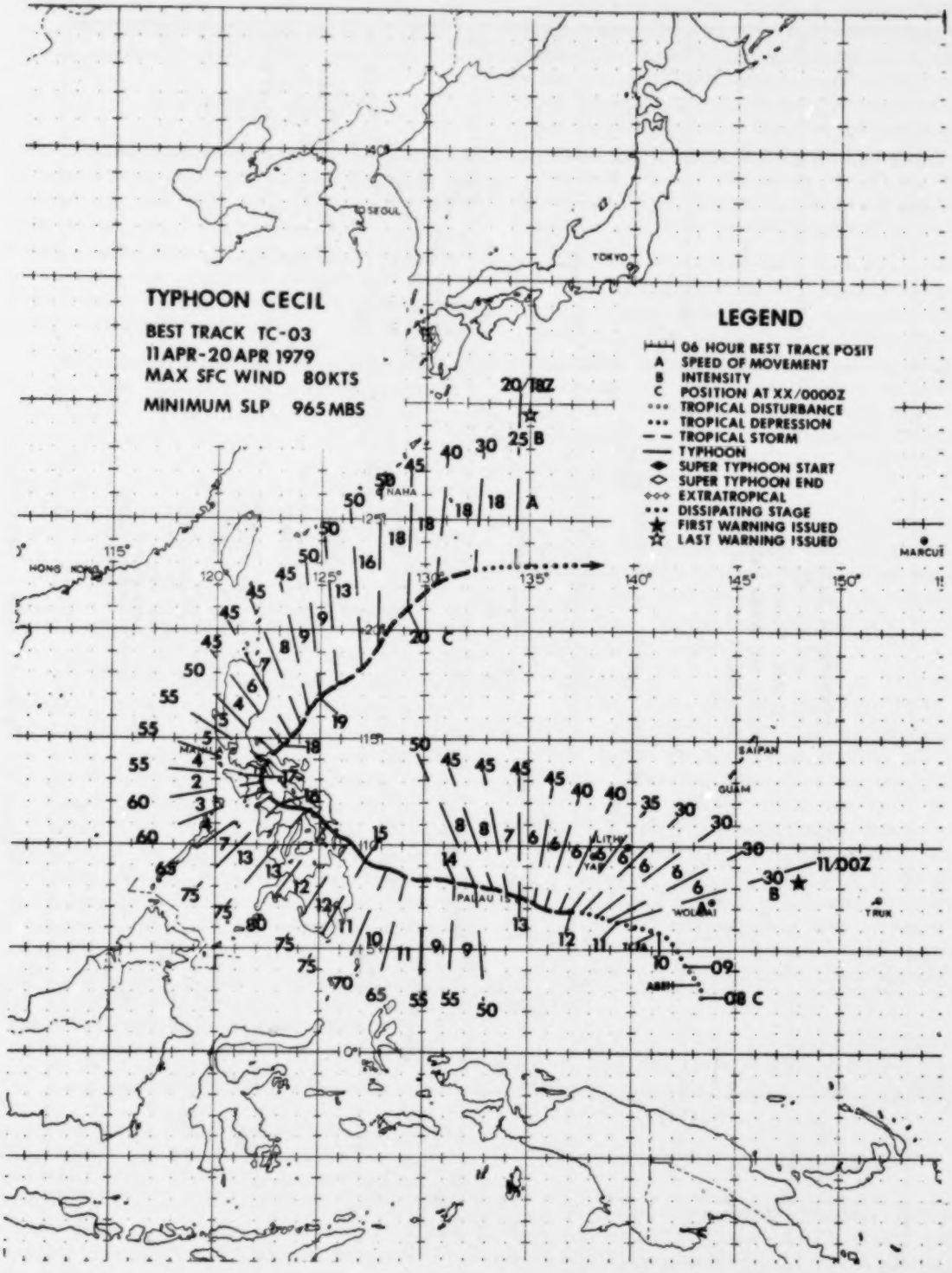


Figure 7. Typhoon Cecil, best track.

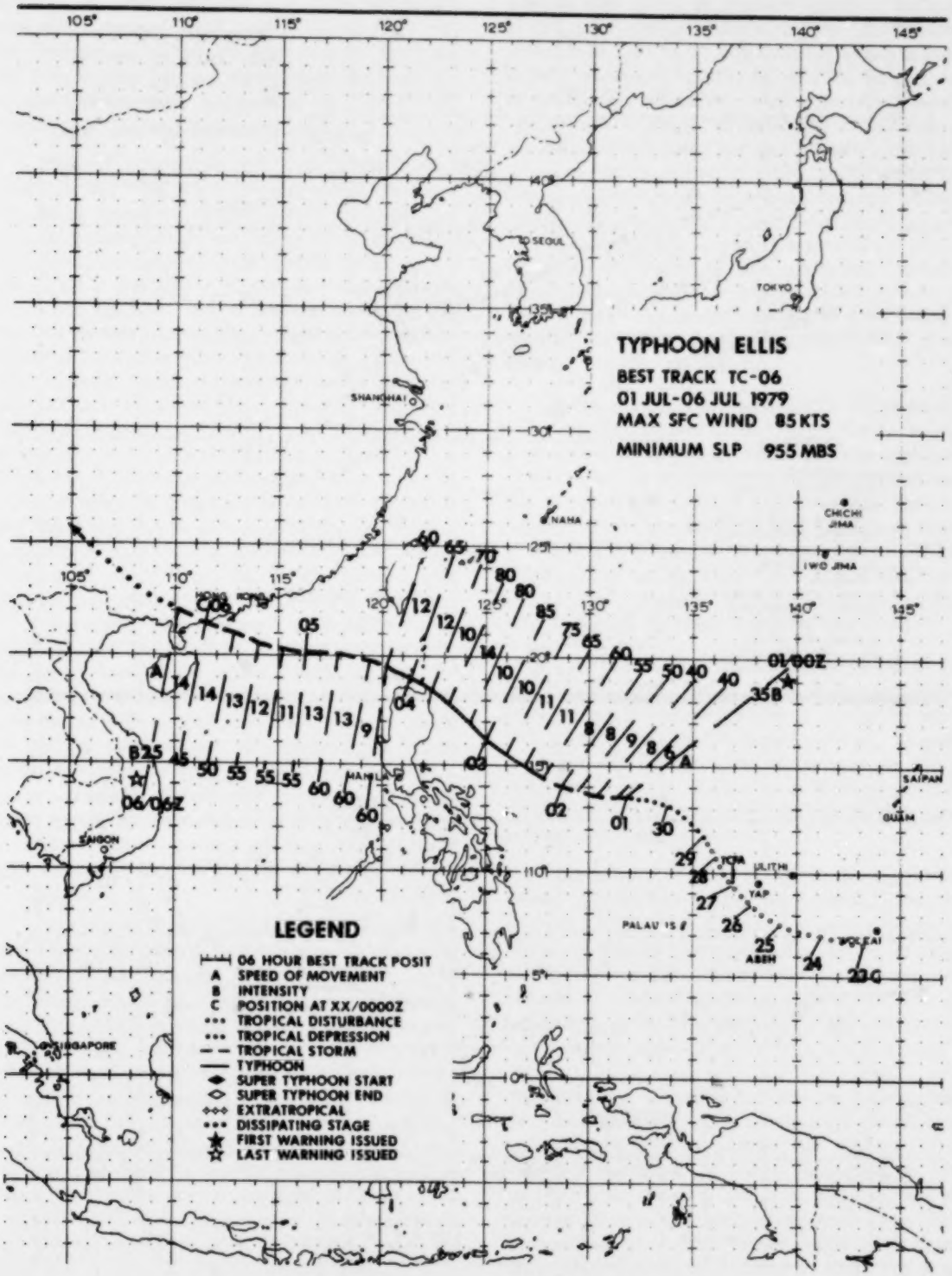


Figure 8. Typhoon Ellis, best track

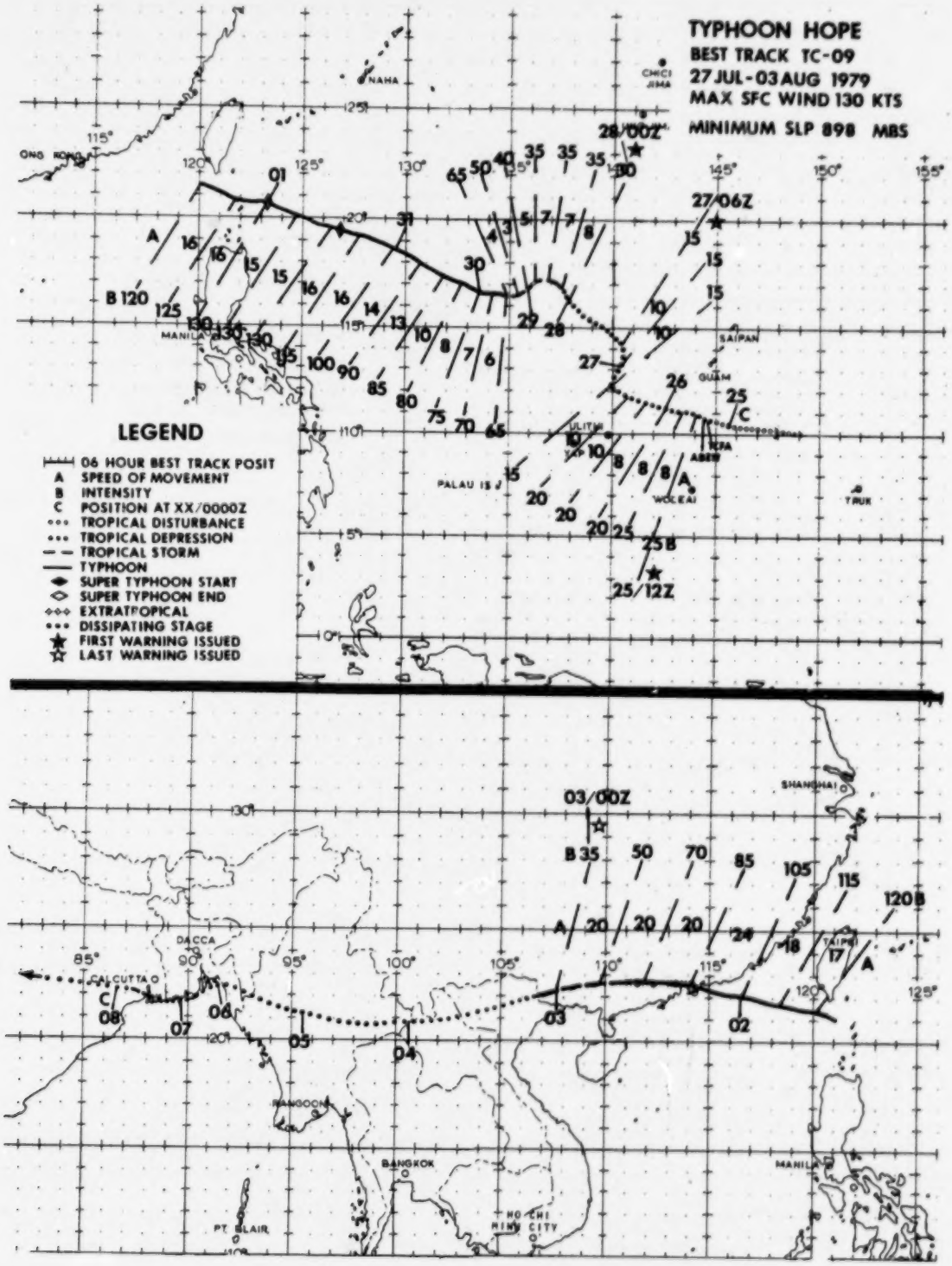


Figure 9. Super typhoon Hope, best track

improved satellite signature, dictated issuance of a TCFA at 0751 on 25 July; the alert box described an area south-west of Guam. Subsequent aircraft reconnaissance at 0900 described a cyclonic circulation with wind speeds of 15-25 kt (8-10 m/sec) and a central pressure of 1,004 mb centred near 11.1° N, 114.5°E. On the basis of these aircraft data and the proximity to Guam, the first warning on TD 09 (Hope) was issued at 1200 on 25 July.

From 25 through 26 July, while TD 09 (Hope) tracked to the WNW, the TUTT axis shifted northward and strong upper-level north-east flow dominated the area. The resultant shear produced by this unidirectional upper-level flow displaced the convective activity to the south-west of the surface circulation, indicating a loss of vertical alignment and subsequent weakening. By 0600 on 27 July, the centre of the convective activity was displaced 120 nm (222 km) south-west of the low-level circulation centre. Surface analyses, at that time, indicated the south-west monsoonal flow was being channelled principally into Tropical Storm Gordon located 750 nm (1,389 km) to the north-west of TD 09 (Hope). With further weakening of Hope expected, a final warning was issued at 0451 on 27 July advising that the area would be closely monitored for possible regeneration. Post-analysis showed that from 1200 to midnight on 27 July, the TUTT weakened with resultant reduced shear over TD 09 (Hope). Conditions for development being improved, reorganization took place and TD 09 began to develop. Unfortunately, the improvement in the surface circulation went unnoticed as it occurred during the night, when only infra-red satellite imagery, on which low-level clouds are difficult to distinguish, was available. An aircraft investigation on the morning of 28 July reported a surface pressure of 999 mb with 45-50 kt (23-27 m/sec) winds in the heavy convective activity south-west of the surface centre. A warning was issued at 0221 on 28 July indicating the regeneration of TD 09 (Hope).

By 0000 on 28 July, Tropical Storm Gordon had moved into the Luzon Straits. Owing to the orographic blocking of the Philippine land mass, the majority of the strong south-west monsoonal flow was diverted into Hope. This increased low-level inflow coupled with decreasing upper-level shear resulted in a much improved vertical structure with feeder band activity developing in the south; aircraft reconnaissance at 2052 on 28 July supported this improved organization trend. Post-analysis indicates that TD 09 (Hope) could have been upgraded to tropical storm intensity 12-24 hours prior to the warning upgrade at 0000 on 29 July, as 35-45 kt (18-23 m/sec) winds were reported in feeder band activity as much as 24 hours earlier. By 0920 on 29 July, a well-defined eye with a central surface pressure of 972 mb and 65-70 kt (33-36 m/sec) surface winds was reported by aircraft data; the warning at 1200 on 29 July upgraded Hope to a typhoon (see figure 9).

The 200 mb analysis at 1200 on 29 July indicated the TUTT had again established itself north of Hope. Owing to the east-west orientation of the TUTT, strong westerly flow along its southern periphery enhanced Hope's upper-level anticyclonic outflow. Aircraft reconnaissance at 2031 on 29 July indicated a sharp decrease in surface pressure to 961 mb with the temperature/dewpoint data correlating to an equivalent potential temperature of 359 K. An empirically derived forecast aid indicated that once the traces intersect, rapid intensification can be expected within 18-30 hours. The intensification equates to a possible mean pressure decrease of 44 mb and a mean wind speed increase of 50-60 kt (26-30 m/sec). Typhoon Hope verified this study 36 hours after the intersection occurred; reconnaissance aircraft reported a surface pressure of 898 mb and wind speeds of 100-120 kt (51-62 m/sec). By 1200 on 31 July, Hope had attained super typhoon intensity of 130 kt (67 m/sec).

Hope entered the Luzon Straits approximately four days after Tropical Storm Gordon. Hope's compact wind structure and a slight weakening trend were noted as Heng Chun on the southern tip of Taiwan (a province of the People's Republic of China) reported sustained winds of 40 kt (21 m/sec) with gusts to 86 kt (44 m/sec) at 1000 on 1 August, as Hope passed 45 nm (83 km) south of the station. Three persons were killed as a result of the torrential rainfall experienced as Hope tracked through the Luzon Straits.

Typhoon Hope made landfall less than 10 nm (19 km) north of Hong Kong at 0530 on 2 August with maximum sustained winds of 70 kt (36 m/sec) and gusts to 110 kt (57 m/sec) reported. Extensive wind and rain damage, three deaths and over 258 injuries were reported. Damage to shipping within Hong Kong harbour was heavy as 17 ships broke their moorings and eight ships collided.

Subsequent to passage over Hong Kong, Hope moved into southern China and weakened. The final warning was issued at 0111 on 3 August, downgrading Hope to tropical storm intensity. Hope's uncomplicated north-west track after development into a typhoon resulted in minimal right-angle track errors with her unexpected acceleration accounting for most of the discrepancy.

Although weakening considerably during passage over south-east Asia, Hope maintained a satellite signature and exited into the northern Bay of Bengal 110 nm (204 km) south-east of Dacca, Bangladesh, at 0500 on 6 August. Strengthened once again by the pre-existing strong south-west monsoonal flow, Hope reintensified from 0000 through 1800 on 7 August with maximum sustained winds of 35 kt (18 m/sec) reported on the 1200 surface analysis on 7 August. A tropical cyclone warning was not issued owing to Hope's proximity to land and her expected movement into north-eastern India within 12 hours.

E. TYPHOON IRVING

Surges in the south-west monsoon frequent the western North Pacific during the early tropical cyclone season and produce widespread convection from the Malay Peninsula to as far east as Guam. During the same period, the 500 mb monsoon trough fluctuates eastward across the South China Sea and occasionally into the Philippine Sea. By late July 1979, an eastward extension of the mid-level monsoon trough was the main synoptic feature west of Guam. The 500 mb trough axis extended along 15°N from northern Viet Nam through the central South China Sea and then eastward into a quasi-stationary low pressure centre over the Philippine Sea.

On 7 August at 1200, a developing surface circulation was observed at the eastern end of the monsoon trough near 14.1°N, 137.7°E. This weak circulation tracked cyclonically around the eastern periphery of the broad 500 mb low pressure centre in the Philippine Sea. Taking on the characteristics of a monsoon depression, Irving was described in aircraft reconnaissance data received from 9 to 11 August as a weak depression with poor vertical alignment and maximum surface winds located 150 to 180 nm (278 to 333 km) west of the surface centre. At this stage, Irving displayed an exposed low-level circulation in satellite imagery with maximum convection located to the west of the surface centre. Ship synoptic data during the same period indicated that 25-35 kt (13-18 m/sec) winds extended outwards 120 nm (222 km) south of the surface centre.

By 11 August, the monsoon surge had weakened and receded westward, leaving a cut-off 500 mb low over the Philippine Sea in the vicinity of Irving's surface circulation. Irving executed a small, tight cyclonic loop on 11 August. During the loop, vertical alignment between the surface and the 500 mb centre improved, and Irving intensified to tropical storm intensity. Simultaneously, a break developed in the 500 mb subtropical ridge to the north, and Irving tracked NNW towards the Ryukyu Islands while intensifying further to typhoon strength. Although originally forecast to recurve south of Japan, strengthening of the 500 mb ridge south-east of Japan caused Typhoon Irving to track over the western East China Sea and accelerate NNE across the Republic of Korea before merging with an extratropical frontal boundary north of Japan.

Although not a spectacular typhoon, Irving's apparent sinusoidal motion, unusually large wind radii, failure to deepen rapidly and damage to the Republic of Korea are noteworthy. Sinusoidal motion of tropical cyclones has been observed for many years, especially when short-term movements are observed by accurate fix platforms such as land radar and reconnaissance aircraft. Sinusoidal motion was observed from 1600 on 13 August to 1800 on 15 August as Irving tracked NNW through the East China Sea. Radar reports from the Ryukyu Islands clearly indicate that Irving oscillated about an over-all NNW track (see figure 10).

The relationship between Irving's surface and 500 mb centres during the earlier stages of development produce unusually large surface wind radii. Synoptic and aircraft data between 2000 on 9 August and 0000 on 12 August indicate that Irving's maximum wind band actually existed 150-200 nm (278-370 km) west of the large, calm-wind surface centre. Although the maximum wind bands eventually migrated towards the surface centre, the wind radii remained large for the duration of Irving. The large wind radii may be related to Irving's developmental interaction with the 500 mb monsoon low and its large areal extent. Irving never became a tight, well-developed tropical cyclone. Aircraft reconnaissance during the period of eyewall development indicated that Irving had a large 30 nm (56 km) diameter eye with the radius of over 30 kt (15 m/sec) winds extending outwards 400 nm (741 km) in the eastern semi-circle.

Typhoon Irving was the first tropical cyclone to strike the Republic of Korea in 1979. Rapidly weakening as he made landfall, Irving spared the southern part of the country from the destructive typhoon force winds he had maintained through most of the East China Sea. However, the country received torrential rains which produced widespread flooding. The hardest hit area was the island of Cheju Do, where 109.7 mm of rain were reported at Cheju. Official estimates reported 150 dead or missing, 1,000-2,000 homeless and approximately $US 10-20 million damage to food and agriculture.

F. SUPER TYPHOON JUDY

Of all the typhoons of 1979, Judy's significance was surpassed only by that of Super Typhoon Tip. Judy eventually developed into the year's second super typhoon, but more important she served as a reminder of how rapidly a minor tropical disturbance can develop into a dangerous tropical cyclone.

Surface synoptic data from the beginning to the middle of August showed that the area south and east of Guam was fairly inactive. Good cross-equatorial flow was present, but only a few flare-ups of convective activity were noted. Surface circulations were broad, ill-defined and transient. By 15 August, however, synoptic and satellite data revealed a tropical disturbance, about 120 nm (222 km) ENE of Truk, which was to eventually become Typhoon Judy.

This area was closely monitored by JTWC, and when the satellite signature began to improve, a TCFA was issued at 2100 on 15 August.

No significant pressure falls were observed over the area as the disturbance drifted slowly to the WNW. A reconnaissance aircraft at 0700 on 16 August was able to define only a weak surface circulation with

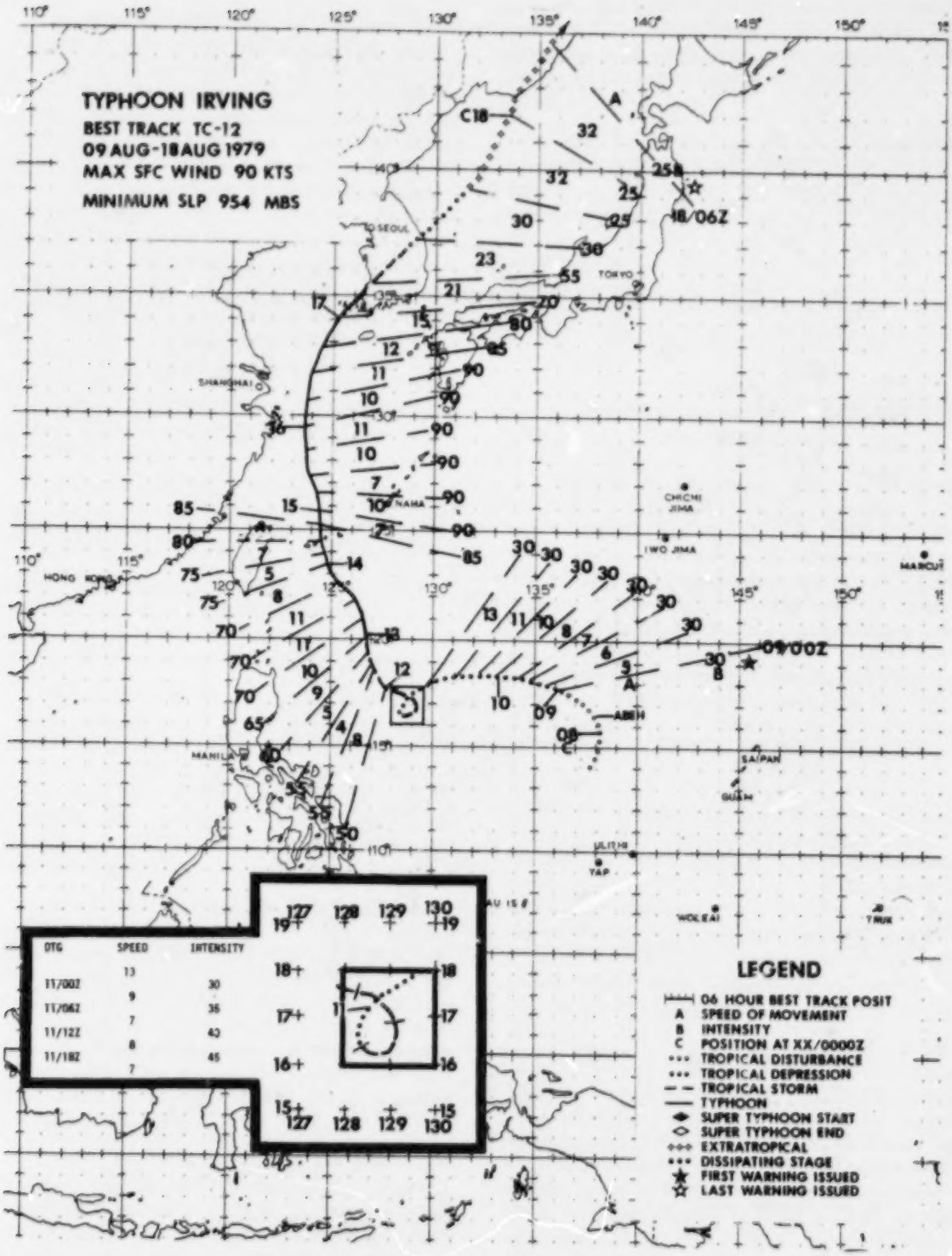


Figure 10. Typhoon Irving, best track

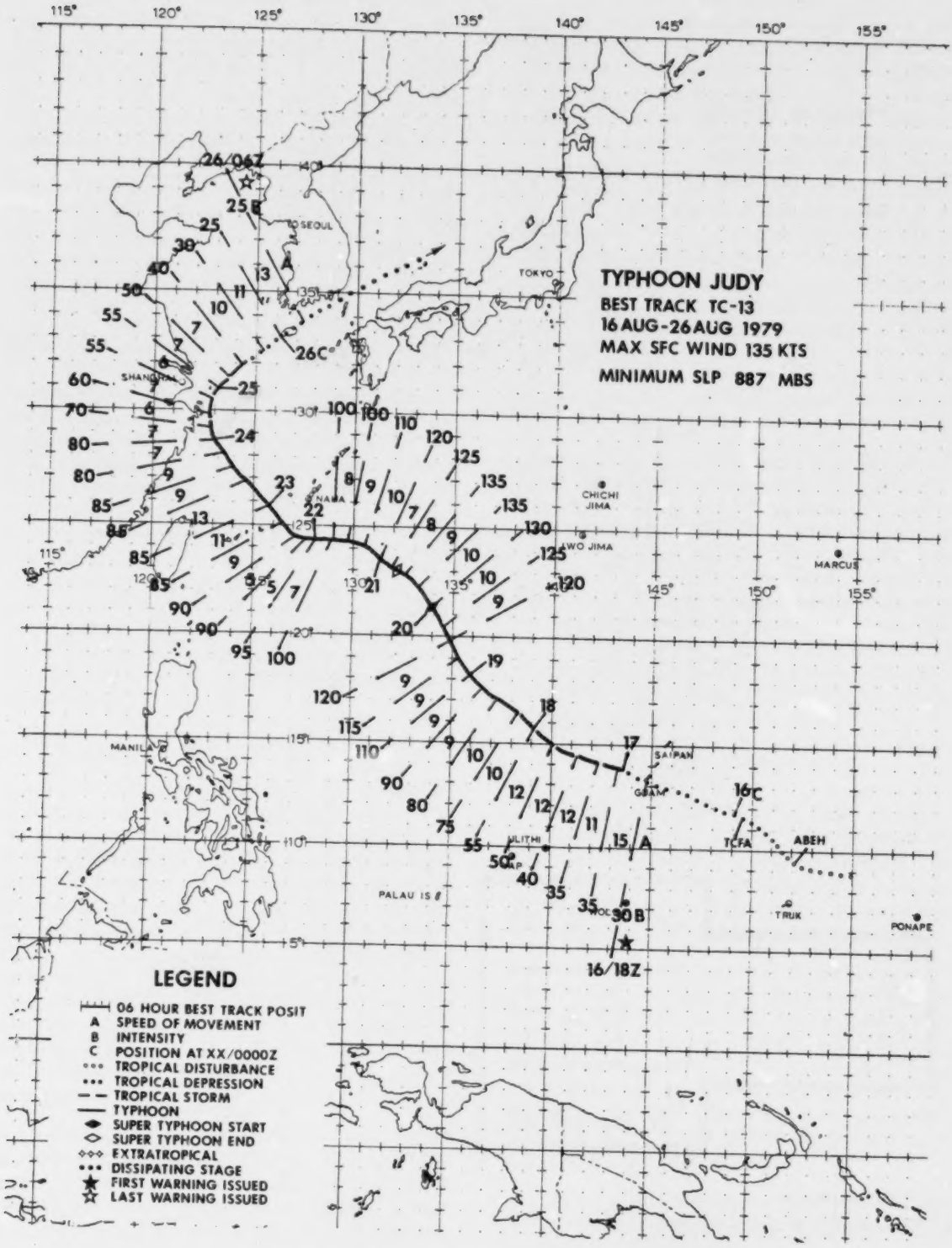


Figure II. Super typhoon Judy, best track

a minimum sea-level pressure (MSLP) of approximately 1,006 mb and observed surface winds in the south semi-circle of 10 kt (5 m/sec) or less.

Rapid intensification was not expected at that time, but at 1635 on 16 August, less than 10 hours after the aircraft investigation, weather radar at Andersen Air Force Base, Guam, located a well-defined circulation centre moving WNW toward Guam at 15 kt (28 km/h). Gradient-level wind reports from Guam, Truk, Palau and Ulithi at 1200 on 16 August also showed that the low-level inflow pattern associated with the disturbance had increased in areal extent. The disturbance continued tracking toward Guam and, at 1800 on 16 August, the centre passed over the Naval Oceanography Command Centre, Guam building on Nimitz Hill. An MSLP of 1,001.0 mb and a wind gust of 51 kt (26 m/sec) were reported at that time. On the basis of this "first-hand" information, JTWC issued the first warning on Tropical Storm Judy at 1900 on 16 August. Post-analysis revealed, however, that Judy did not reach tropical storm strength until 0000 on 17 August.

Judy intensified steadily while following a nearly climatological west-northwest track at 10-12 kt (19-22 km/h) for the next 24 hours. She reached typhoon strength at approximately 0300 on 18 August (see figure 11). After that, a long-wave trough in the mid-level westerlies, moving over Japan toward the Pacific, fractured the subtropical mid-tropospheric ridge north of Judy, allowing her to track more to the north-west.

During the next 36-hour period, after reaching typhoon strength, Judy's central pressure dropped 69 mb and she attained super typhoon strength at 0000 on 20 August. Her lowest central pressure, 887 mb, was measured by a reconnaissance aircraft at 2145 on 19 August. Three distinct, concentric wall clouds were also noted at that time. Super typhoon intensity was weakening thereafter.

Forecast aids indicated that Judy would pass to the south of Okinawa, but on the basis of her persistence track and the deep trough that existed over Japan at 500 mb, Judy was forecast to recurve east of Okinawa. The numerical forecasts had not been verifying well up to that point; and, thus the well-entrenched trough was forecast to persist. The numerical forecasts proved to be correct, however, and Judy passed south of Okinawa before beginning to recurve into the East China Sea.

The rapidly intensifying ridge was expected to drive Judy into the Asian mainland south of Shanghai. The 500 mb analysis at 1200 on 24 August provided the first indication that Judy was not going to make landfall. At that time, she was just off the Chinese coast, but north of the mid-level ridge axis. Three-hourly synoptic reports from Sheng-Szu were watched closely and when the winds backed from east at 40 kt (21 m/sec) to north at 35 kt (18 m/sec), there was little doubt that Judy had, in fact, recurved to the north-east.

As Judy recurved, she was downgraded to tropical storm strength on the basis of land synoptic data. Transition to an extratropical system occurred at 1200 on 26 August while Judy passed through the Korea Strait.

Since the typhoon was still relatively weak while passing over Guam, damage there was insignificant. Damage to Okinawa was also minimal, even though sustained winds of 40 kt (21 m/sec) were experienced for a 28-hour period. The southern part of the Republic of Korea did not fare as well, however. There 111 people were killed, over 8,000 houses were inundated, 57 vessels were destroyed and thousands of hectares of crops were ruined by Judy's torrential rains and strong winds.

G. TYPHOON MAC AND TROPICAL STORM NANCY

Typhoon Mac developed from a weak surface circulation north-east of Yap in September 1979. This circulation tracked westward, reaching tropical storm intensity by 0000 on 16 September. Mac followed the climatological intensification rate for tropical cyclones approaching the Philippines and reached typhoon intensity prior to making landfall (see figure 12). Frictional effects caused Mac to weaken slowly as he tracked across southern Luzon towards the South China Sea. The unexpected development of Tropical Storm Nancy east of Hainam Dao (Hainan Island) influenced Mac's track in the South China Sea (see figure 13).

JTWC's real-time forecasts do not always reflect the actual intensity of a tropical cyclone. Rapid intensification or weakening, peripheral data unavailable owing to geographical restrictions and tight maximum wind bands, which are not initially detected, all reduce the accuracy of intensity estimates provided in tropical cyclone warnings. These intensity discrepancies often go unrecognized until discovered during post-analysis, as in the case of Typhoon Mac.

Reanalysis of aircraft reconnaissance data from 16 to 18 September indicates that Mac most probably intensified to typhoon intensity by 1800 on 16 September. During the period 16 to 18 September, aircraft reconnaissance at 0503 on 16 September reported 68 kt (35 m/sec) at 457 m and 60 kt (32 m/sec) on the surface prior to encountering moderate turbulence, which forced the aircraft to climb through the overcast stratocumulus cloud layer above. Subsequent reconnaissance data at 0810 on 17 September confirmed typhoon intensity by locating 80-90 kt (41-46 m/sec) surface winds in a 10-mn (19 km) wide band tucked under the strong eastern feeder band. Mac made landfall prior to the next scheduled aircraft fix with

geographical constraints severely reducing peripheral data collection.

Although real-time data were available which indicated Mac had possibly reached typhoon intensity, the isolated reports of strong winds were dismissed as gusts associated with lower velocity sustained winds. During post-analysis, the reconnaissance data were re-examined using an intensity study of tropical cyclones crossing the Philippines. Reanalysis of the period between 1800 on 15 September and 0000 on 18 September shows, in fact, that Mac intensified to typhoon intensity before weakening from frictional effects over Catanduanes Island on 18 September.

The unexpected development of a second tropical cyclone in the South China Sea produced a series of track and intensity modifications in Typhoon Mac. Upon exiting the Philippines, Mac, which was originally forecast to track WNW into the South China Sea, began a Fujiwhara interaction with the rapidly developing Tropical Storm Nancy located near Hainam Dao. Instead of tracking WNW, Mac tracked NNW, skirting Cubi Point Naval Air Station, Philippines, on his new track toward Hong Kong. Strong anticyclonic outflow from Nancy sheared Mac's convection towards the south-west with aircraft reconnaissance reporting an exposed low-level circulation of 30-35 kt (15-18 m/sec) intensity on 20 September.

Weak steering currents allowed Nancy to take a cyclonic track across southern Hainam Dao before heading south-westward into Viet Nam. Nancy's south-westward track towards landfall forced Mac further north than originally forecast. Mac eventually passed just south of Hong Kong. Ironically, Nancy's development, which caused Mac to track towards Hong Kong, also helped to spare Hong Kong from potential typhoon force winds. Nancy's upper-level outflow, which dominated the South China Sea from 19 to 23 September, produced strong vertical shear over Mac and slowed his rate of reintensification. Typhoon Mac only reached minimal tropical storm intensity prior to making landfall west of Hong Kong.

H. TYPHOON OWEN

Typhoon Owen developed from a disturbance which tracked south of Guam during 20 September 1979. Two days later, satellite imagery showed that the system was organizing at the same time that aircraft reconnaissance data indicated a definite surface circulation with a 1,000 mb central pressure. The prompted JTWC to issue a tropical depression warning on the system at 0000 on 22 September.

During the two days prior to and one day after 22 September, the system moved on a generally westward track at 5 to 8 kt (9 to 15 km/h). This speed and direction were in good agreement with climatological tracks. Also, the 500 mb analysis showed a strong subtropical ridge which indicated westward steering. On the basis of this information, JTWC forecast westward movement for the first eight warnings. However, Owen unexpectedly turned sharply to the north and began moving at speeds of 15 kt (28 km/h).

Post-analysis revealed a possible reason for this movement. An upper-level trough was evident on the 200 mb analysis just west of the cyclone. Southerly winds of 50 kt (26 m/sec) were observed on the eastern periphery of the trough. Considerable vertical shear existed in the layer from 500 mb to 200 mb. It appears that the steering and depth of this upper-level trough rather than 500 mb steering was the dominant feature in Owen's movement. Under its influence, Owen tracked generally northward throughout his lifetime, although undergoing major changes in speed. He slowed to a barely perceptible 1 kt (2 km/h) movement just north-east of Okinawa (at the latitude of the subtropical ridge axis) and then dramatically accelerated to 24 kt (44 km/h) 36 hours later under vertically consistent westerly steering. At this time, Owen made landfall near Osaka, Japan, and began weakening in intensity while still accelerating to 47 kt (87 km/h). Eventually, he turned into an extratropical system but not before reaching a maximum intensity of 110 kt (57 m/sec) on 26 September (see figure 14).

I. TYPHOON SARAH

Typhoon Sarah spawned in the monsoonal trough during late September 1979. This trough extended from the south-western portion of the South China Sea toward Luzon. A north-east monsoon surge existed north of the trough, while the south-west monsoon dominated the area south of the trough. The circulation was steered initially by the south-west monsoon and then later by the first north-east surge of the autumn from the Asian mainland. During the last few days of September, the circulation meandered slowly toward Luzon under the influence of the south-west monsoon, and then looped over Luzon during the first three days of October as a mid-tropospheric short-wave trough moved eastward north of Luzon. Once the short-wave trough had moved east of the circulation, the north-east surge intensified and became more of an influence as the circulation finished its loop and began its SSW track.

On 5 and 6 October, Sarah, now a tropical storm, apparently was again influenced by another mid-tropospheric short-wave trough which moved across Sarah's longitudinal position and induced the brief eastward movement in her track. At this time, the south-west monsoon also increased in intensity and may have been another factor in steering Sarah eastward. For almost the entire period that Sarah was tracking southward, there was a weakness in the mid-tropospheric ridge between the Philippines and the Asian mainland, enabling Sarah's track to be influenced by short-wave troughs. This weakness in the ridge resulted in mid-tropospheric

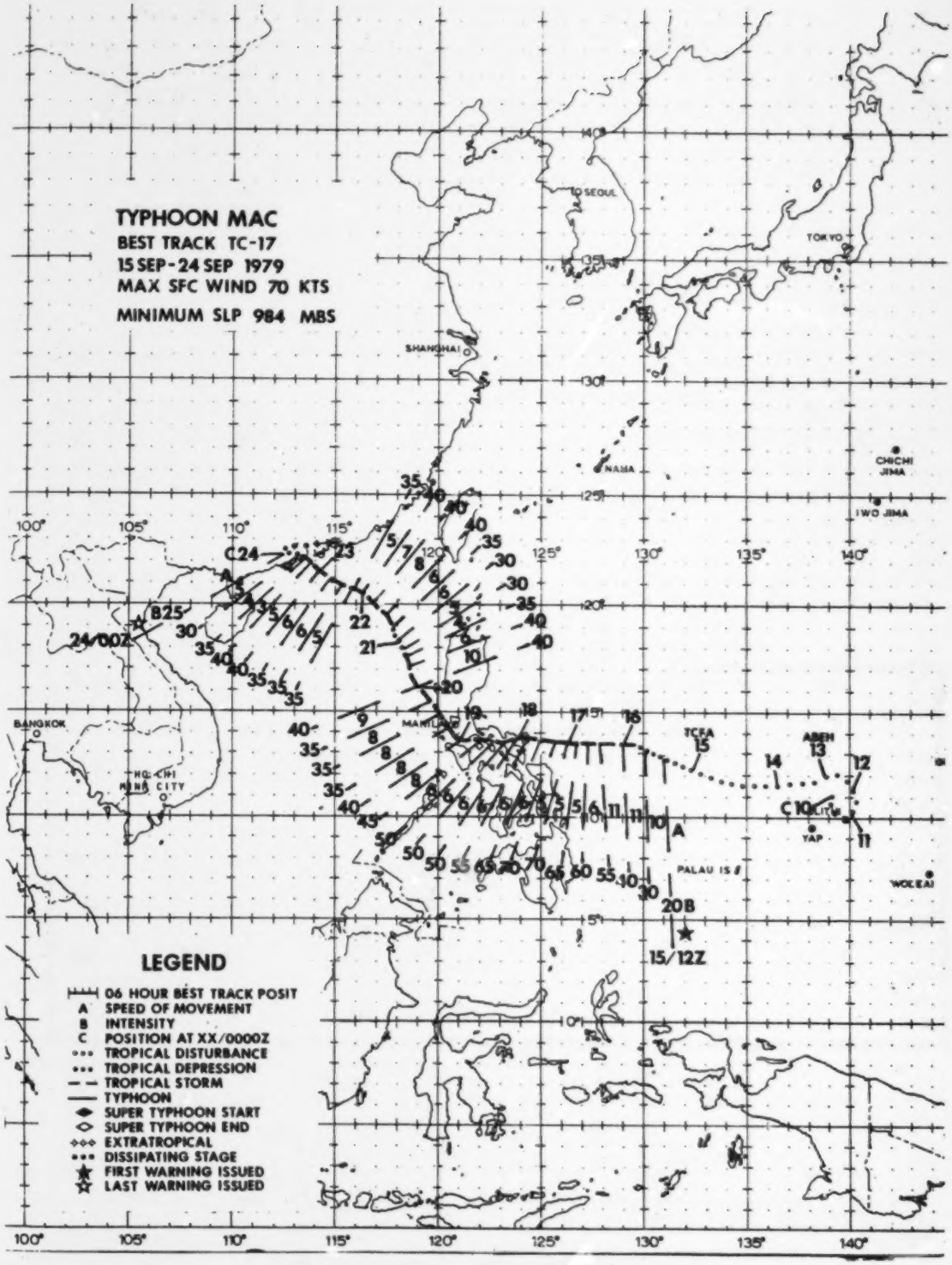


Figure 12. Typhoon Mac, best track

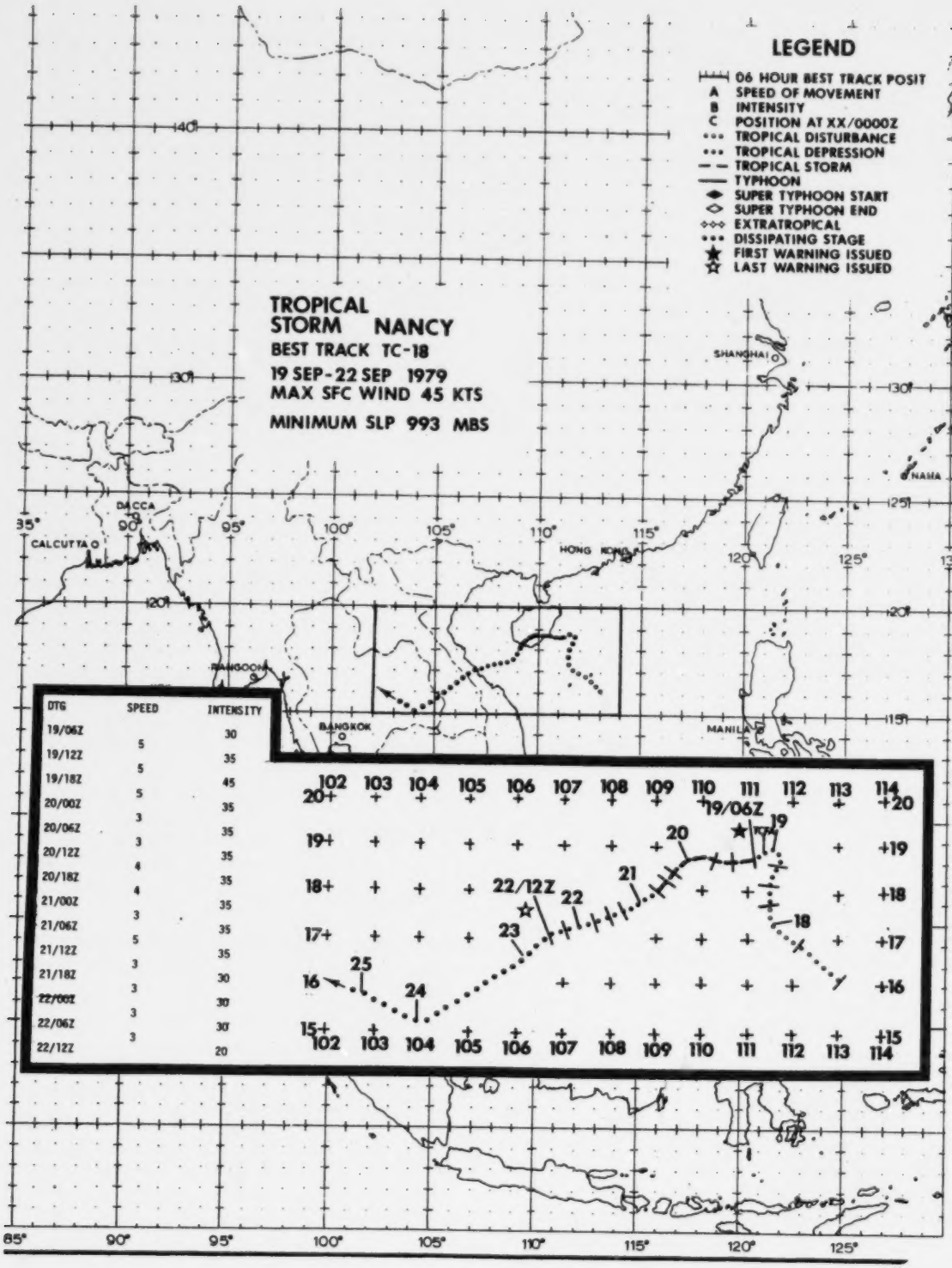


Figure 13. Tropical storm Nancy, best track

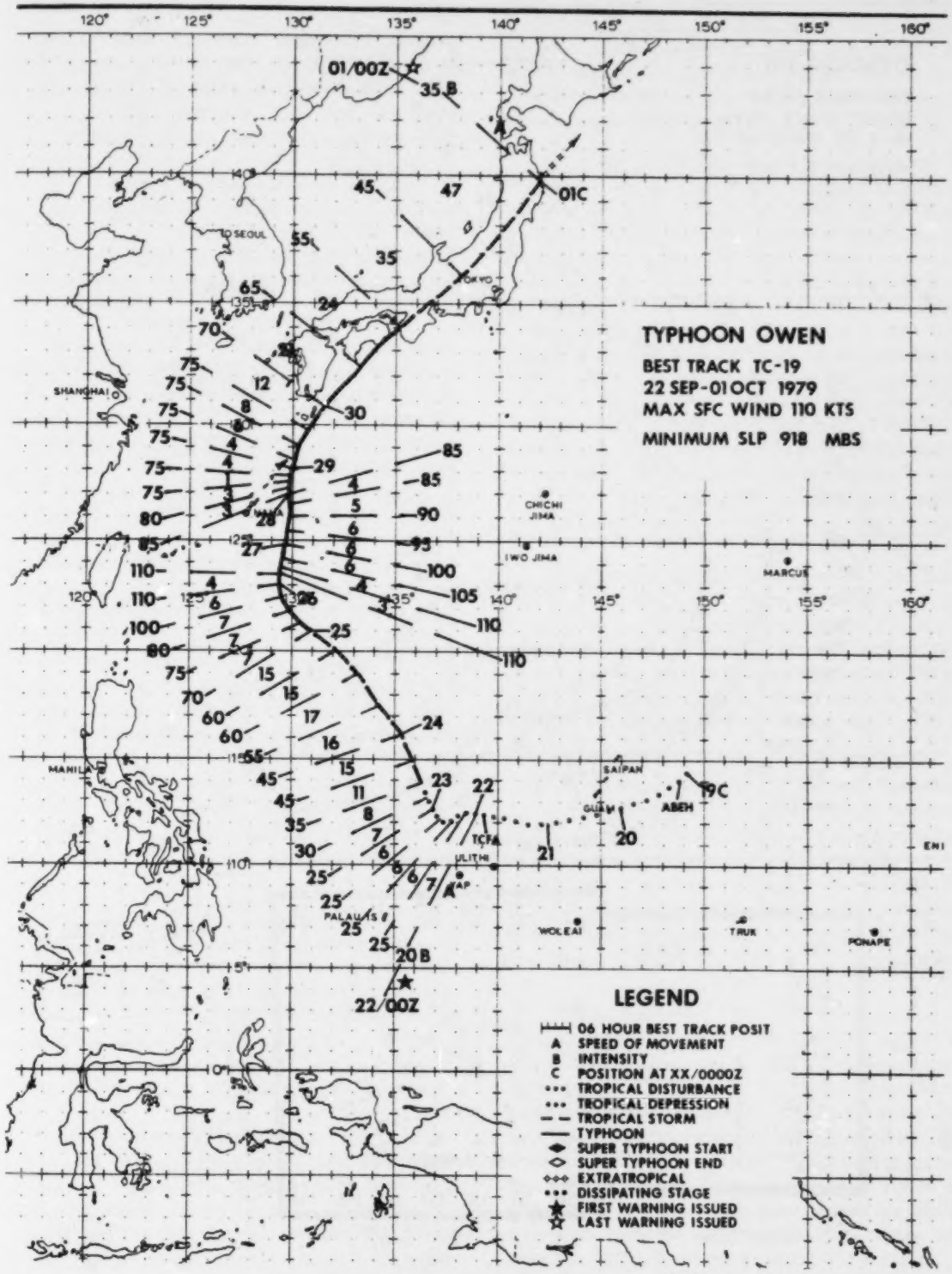


Figure 14. Typhoon Owen, best track

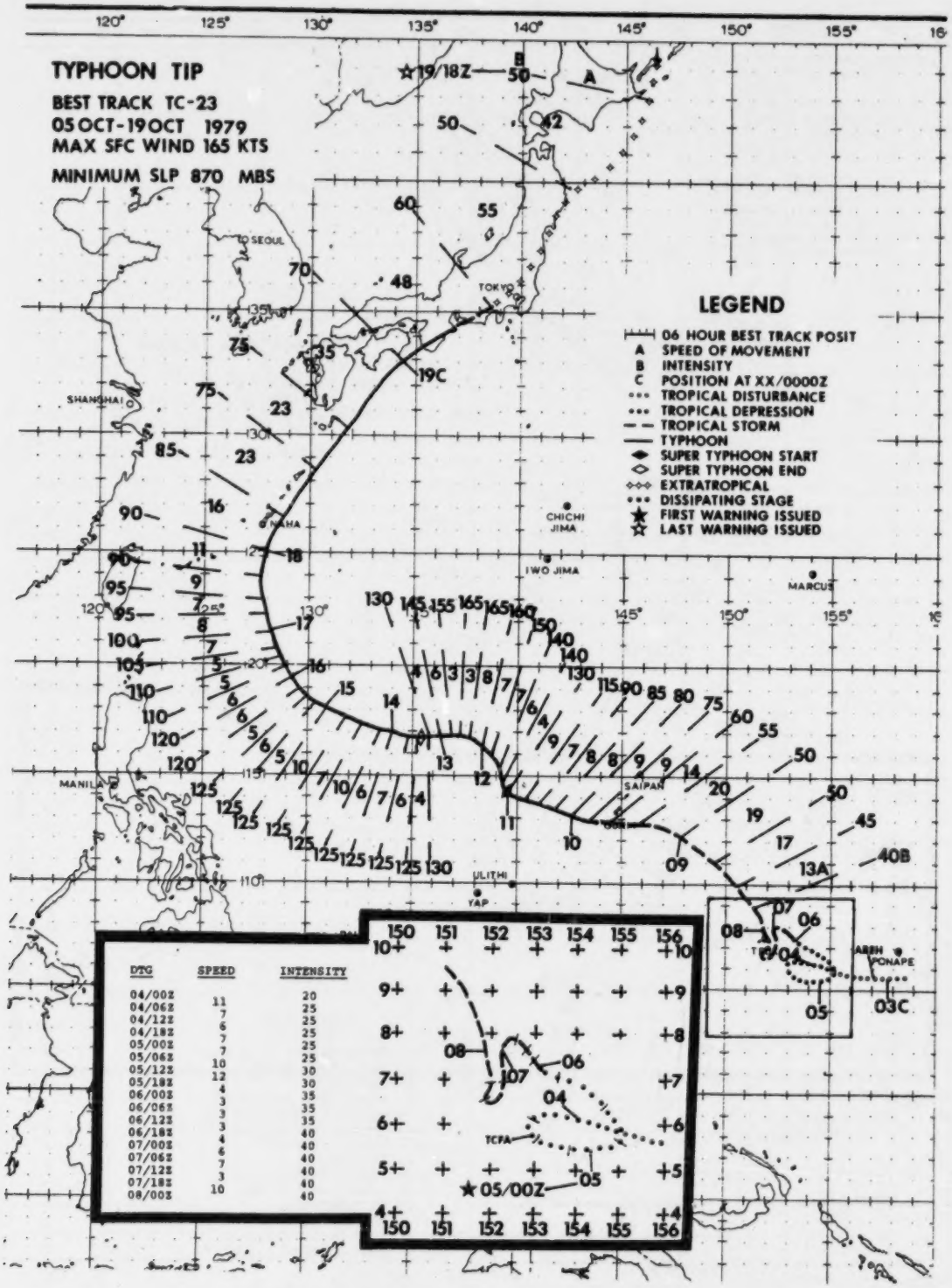


Figure 15. Super typhoon Tip, best track

flow that was too weak to have a significant effect on the steering of Sarah. This weakness allowed the surface winds to dictate Sarah's direction of motion through the first eight days of October.

During Sarah's depression stage, strong easterlies in the upper-troposphere restricted Sarah's outflow to the north-east, thus inhibiting development into a tropical storm. As Sarah proceeded southward, the easterlies decreased in strength, outflow increased and Sarah intensified to tropical storm and then typhoon strength. It is very interesting to note that Sarah intensified to typhoon strength while tracking southward, which is quite unusual for a tropical cyclone. Several aircraft reconnaissance flights reported that Sarah had attained typhoon strength even though her cloud structure was not well organized.

During the first several days of October, when Sarah was slowly developing to typhoon strength and moving south, Palawan Island and the central Philippines were battered by high winds and rain. These areas were inundated by flooding and land-slides which caused massive crop damage and death. Many villages were cut off from any source of food, fresh water and other necessities for survival. Four deaths were attributed to Sarah. On 8 October, Sarah finally began to track westward and the weather finally cleared over Palawan Island and the central Philippines. Sarah's change in track was due to the strengthening of the mid-tropospheric ridge north of Sarah from Luzon across the South China Sea into Asia. Aircraft reconnaissance early on 9 October reported that Sarah's structure had become better organized. Earlier aircraft flights reported that Sarah was not vertically aligned, but on 9 October the mid-level centre had become vertically aligned with the surface centre. With vertical alignment and improved upper-level outflow, Sarah's intensity increased to 110 kt (57 m/sec) as she became a most impressive storm (see figure 15). This is in contrast to her unusual origin.

After Sarah reached peak intensity early on 10 October, she began to weaken slowly as she tracked to the WNW. Sarah continued on a WNW track until dissipation over Viet Nam on 17 October. After 20 days, she dissipated within 300 nm (556 km) of her origin as a monsoon depression on 28 September.

J. SUPER TYPHOON TIP

Super Typhoon Tip was the most significant typhoon of the 1979 season, and possibly the most significant tropical cyclone this century. Forty aircraft reconnaissance missions were flown on Tip, which produced 60 fixes and thus made it one of the most closely watched cyclones in recent memory. Aircraft and synoptic data showed that Tip achieved the lowest sea-level pressure ever observed in a tropical cyclone (870 mb) and also had the largest circulation pattern on record, nearly 1,200 nm (2,222 km) in diameter.

Satellite and synoptic data during the early part of October revealed an active monsoon trough that extended from the Marshall Islands through the Caroline Islands to Luzon. Three distinct circulations developed in this trough: one near Manila, which would become Typhoon Sarah; another south-west of Guam, which would become Tropical Storm Roger; and the last between Truk and Ponape, which was destined to become Super Typhoon Tip.

It is not possible to discuss the development of Tip without, at the same time, examining the development of TS Roger. The surface analysis for 0000 on 3 October showed the three circulations in the monsoon trough with strong cross-equatorial flow, most of which was feeding into TS Roger. This situation was enhanced, in part, by an extratropical trough north of Roger over southern Japan. The split in the surface flow pattern near Guam tended to keep Tip from developing rapidly while south-east of Guam. The upper-level analysis at the same time showed a large anticyclone north of Guam in close association with TS Roger and a developing TUTT cell about 300 nm (556 km) east of Marcus Island. The TUTT cell was moving slowly westward. Only strong upper-level northeasterlies existed over Truk and Ponape.

The satellite signature of the tropical disturbance near Truk continued to show improvement despite the initially unfavourable upper-air pattern. A TCFA was issued at 0900 on 4 October, when a reconnaissance aircraft found a closed surface circulation about 120 nm (222 km) south-east of Truk with an MSLP of 1,003.9 mb and a maximum observed surface wind of 25 kt (13 m/sec).

A reconnaissance aircraft fixed the disturbance the following day about 100 nm (185 km) south-east of the previous position. On the basis of indications of continual development, the first warning on TD 23 was issued at 0000 on 5 October. Although the surface pressure did not drop significantly, the observed surface winds increased, and as a result, TD 23 was upgraded to Tropical Storm Tip at 0000 on 6 October.

During the period from 0000 on 5 October to 1800 on 7 October, TS Tip gave the JTWC forecasters a striking example of what the term "erratic movement" really means. TS Tip first executed a cyclonic loop south-east of Truk, then accelerated to the north-west, only to stall and meander to a position south of Truk. It was difficult to keep track of TS Tip's surface position during this period. The best track is based almost entirely on aircraft surface positions, because the satellite fixes were based on upper-level outflow centres, and even the 700 mb centre, as observed by aircraft reconnaissance, was considerably displaced from the surface centre. Changes in the surface wind direction reported by Truk assisted JTWC in monitoring TS Tip during this period of erratic behaviour.

Post-analysis shows that Tip's slow development and early erratic behaviour are related to the weak, yet extensive, circulation patterns that were associated with TS Roger. While near Truk, TS Tip was still competing with TS Roger for strong southerly surface inflow and, until 8 October, was coming out second best. During the period of erratic movement, JTWC continued to forecast a north-westward track with passage south of Guam. These forecasts were based primarily on the mid-level steering winds observed at Guam and obtained by the reconnaissance aircraft. The fairly strong winds from the south-east were expected to steer Tip toward Guam. However, at this stage of development, Tip was evidently too far south of this wind band and the steering in the immediate vicinity of Tip remained weak.

On 8 October, the expected north-west movement began. Roger was far to the north becoming extratropical, and the southerly winds that had been flowing north began to veer toward Tip. The TUTT cell earlier near Marcus Island migrated to a position north-west of Guam, affording Tip an excellent outflow channel to the north. Synoptic and subsequent aircraft data revealed that the south-easterly mid-level winds finally began to influence TS Tip, and the 0208 aircraft fix on 8 October confirmed that Tip was heading towards Guam at approximately 13 kt (24 km/h). The MSLP dropped to 995 mb and surface winds were 40 kt (21 m/sec).

Tropical Storm Tip continued to intensify and accelerate, eventually to 20 kt (37 km/h), as it headed toward Guam. Until six hours before reaching Guam, Tip's persistence track and JTWC's forecasts indicated that it would pass directly over the centre of the island. Six hours before expected landfall, however, reconnaissance aircraft and radar positions from Andersen Air Force Base showed that TS Tip had turned to the west. Tip actually passed south of Guam, reaching its closest point of approach at about 25 nm (46 km) south of the southern end of the island at 1015 on 9 October. Maximum winds of 48 kt (25 m/sec) with gusts to 64 kt (33 m/sec) were recorded at the Naval Oceanography Command Centre on Nimitz Hill. Andersen Air Force Base recorded 165 mm of rain between 1800 on 8 October and 1800 on 9 October, and an additional 66 mm between 1800 and 1900 on 9 October.

Shortly after passing Guam, Tip reached typhoon strength and continued on a basic WNW track (see figure 16). The analyses over the next few days showed that Typhoon Tip was moving into an area of strong upper-level divergence which appeared to cover most of the western Pacific. Rapid intensification was forecast on the basis of the favourable upper-level pattern and the continued drop in surface pressure as observed by the reconnaissance aircraft. Intensification was much more rapid than expected, however, as the pressure between 9 and 11 October dropped 98 mb to 898 mb. Tip reached super typhoon strength at that time with maximum winds of 130 kt (67 m/sec) reported by aircraft reconnaissance. The surface analyses revealed that the circulation pattern associated with Typhoon Tip had increased to a diameter of 1,200 nm (2,222 km), which broke the previous record of 720 nm (1,333 km) set by Typhoon Marge in August 1951.

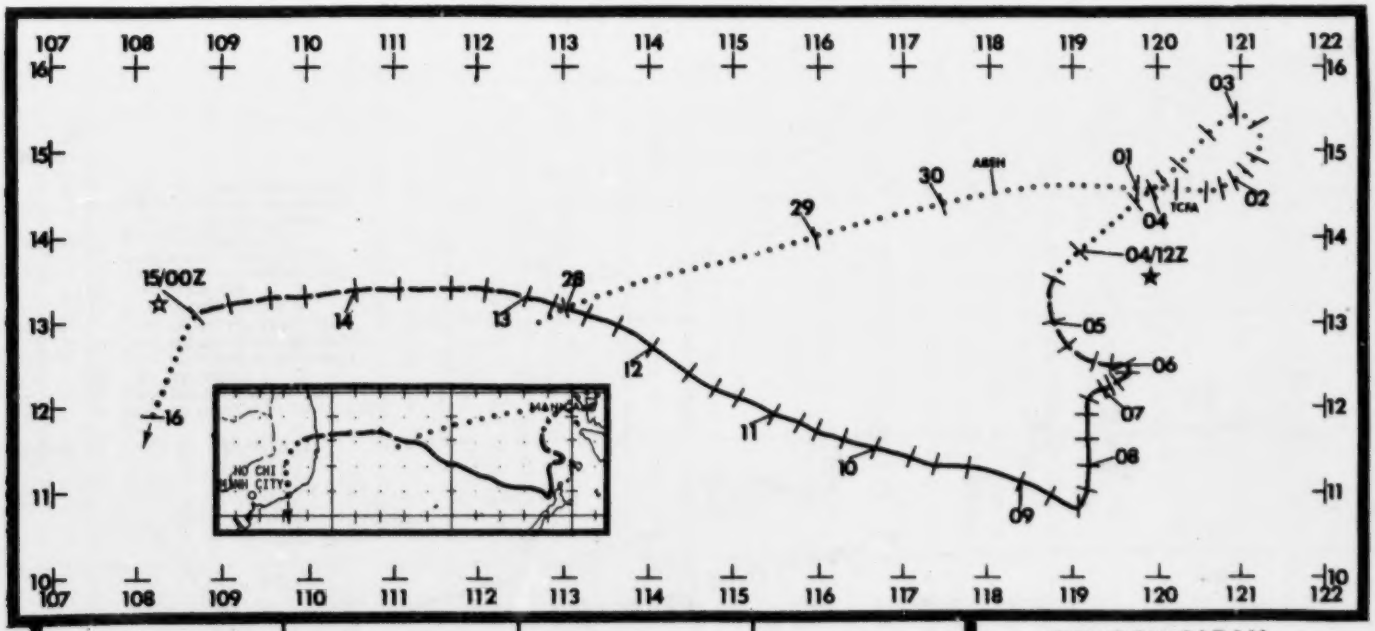
Super Typhoon Tip intensified still further, and at 0353 on 12 October, a reconnaissance aircraft recorded the lowest sea-level pressure ever observed in a tropical cyclone: 870 mb. This was 6 mb lower than the previous record set by Super Typhoon June in November 1975. The 700 mb height was 1,944 m and the 700 mb temperature within the eye was an exceptionally high 30^{0} C. Tip maintained super typhoon strength for the next 54 hours while moving to the north-west at between 3 and 7 kt (6 and 13 km/h). Estimated maximum wind intensity of 165 kt (85 m/sec) was reached at 0600 on 12 October.

The immense circulation pattern associated with Typhoon Tip extended from the surface through 500 mb (and probably higher) and essentially split the subtropical midtropospheric ridge south of Japan. This would have allowed an average typhoon to recurve sharply to the north, but Tip was an atypical system and the north-westward movement persisted for the next three days. Steering forecast aids were useless during this period because they merely steered Tip in its own large storm-induced flow. Persistence and climatology became the primary forecast aids during this stage in Tip's life.

From 13 to 17 October the radius of surface and gradient-level 30 kt (15 m/sec) or greater winds extended over 600 nm (1,111 km) from Typhoon Tip's centre. The radius of over 50 kt (26 m/sec) winds was over 150 nm (278 km). The aircraft reconnaissance data likewise showed that 700 mb winds of 105 kt (54 m/sec) existed more than 120 nm (222 km) from Tip's centre during this period.

After 17 October, Tip began to weaken as the large circulation pattern began to shrink. This, together with the effects of a mid-level trough moving towards Japan from China, caused Tip to begin tracking northward. By 18 October, Tip was accelerating to the north-east under the influence of the increased mid-level southwesterlies. During recurvature, Tip passed within 35 nm (65 km) of Kadena Air Base on Okinawa, which reported maximum sustained winds of 38 kt (20 m/sec) with gusts to 61 kt (31 m/sec).

At approximately 0100 on 19 October, after reaching a forward speed of between 35 and 45 kt (65 and 83 km/h), Typhoon Tip, with maximum winds of 70 kt (36 m/sec), made landfall on the Japanese Island of Honshu, about 60 nm (111 km) south of Osaka. Synoptic and radar data from stations on the island showed that Tip maintained a speed in excess of 45 kt (83 km/h) as it passed to the north of Tokyo and eastward into the Pacific Ocean. According to



DTG	SPEED	INTENSITY
04/12Z		30
04/18Z	5	35
05/00Z	5	40
05/06Z	4	40
05/12Z	3	40
05/18Z	2	40
06/00Z	2	40
06/06Z	1	40
06/12Z	1	45
06/18Z	1	50
07/00Z	1	60
07/06Z	2	75
07/12Z	2	75

DTG	SPEED	INTENSITY
07/18Z	3	75
08/00Z	3	75
08/06Z	3	75
08/12Z	2	75
08/18Z	3	75
09/00Z	4	85
09/06Z	6	90
09/12Z	5	90
09/18Z	4	95
10/00Z	4	110
10/06Z	3	110
10/12Z	3	100

DTG	SPEED	INTENSITY
10/18Z	3	100
11/00Z	4	100
11/06Z	4	90
11/12Z	3	85
11/18Z	3	75
12/00Z	4	75
12/06Z	5	70
12/12Z	5	65
12/18Z	4	65
13/00Z	4	60
13/06Z	4	60
13/12Z	5	60
13/18Z	6	60

DTG	SPEED	INTENSITY
14/00Z	6	55
14/06Z	5	50
14/12Z	5	50
14/18Z	5	35
15/00Z	5	20

TYPHOON SARAH
BEST TRACK TC-22
04 OCT-15OCT 1979
MAX SFC WIND 110 KTS
MINIMUM SLP 929 MBS

LEGEND

- 06 HOUR BEST TRACK POSIT
- A SPEED OF MOVEMENT
- B INTENSITY
- C POSITION AT XX/0000Z
- TROPICAL DISTURBANCE
- TROPICAL DEPRESSION
- TROPICAL STORM
- TYPHOON
- SUPER TYPHOON START
- SUPER TYPHOON END
- EXTRATROPICAL
- DISSIPATING STAGE
- FIRST WARNING ISSUED
- LAST WARNING ISSUED

Figure 16. Typhoon Sarah, best track

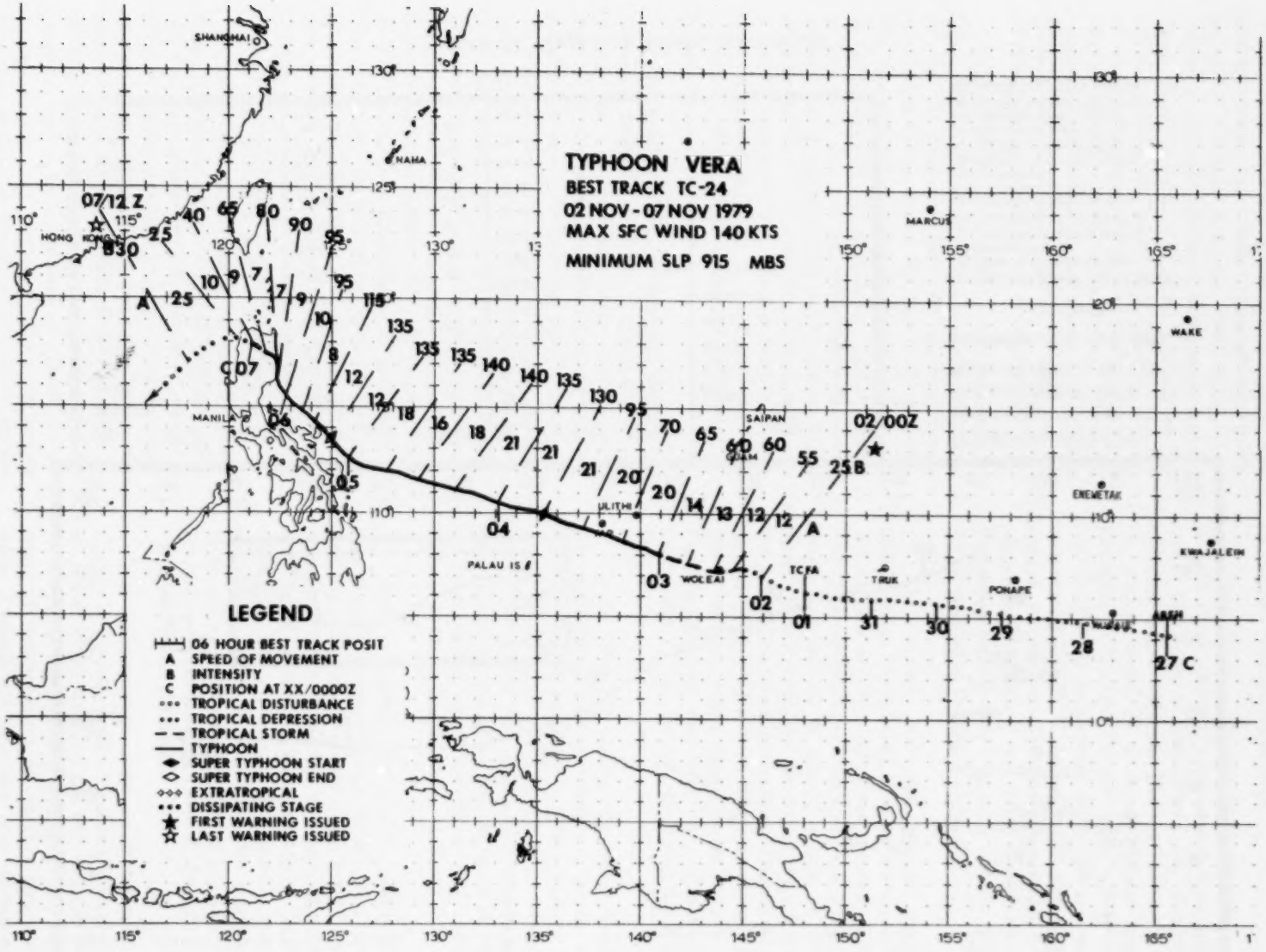


Figure 17. Super typhoon Vera, best track

satellite imagery, Tip completed extratropical transition over Honshu.

The extratropical low pressure centre (the remnants of Tip) maintained winds of storm force, 48 kt (25 m/sec), until 21 October, when it moved to a position east of Kamchatka and finally began to fill rapidly.

The majority of the severe damage occurred in Japan, where the agricultural and fishing industries sustained losses into the millions of dollars. Flooding from Tip's rains also breached a fuel-retaining wall at Camp Fuji, WNW of Yokosuka. The fuel caught fire, causing 68 casualties, including 11 deaths.

Considering the size and strength of Super Typhoon Tip, the western Pacific fared well. Luckily, the maximum intensity was reached while the system was still far from any inhabited areas. The potential for mass destruction was always there, but from a strictly meteorological standpoint, Tip was also a thing of great beauty.

K. SUPER TYPHOON VERA

Vera, the fourth and final super typhoon of 1979, originated in an active near-equatorial trough which extended through the Caroline and Marshall Islands. Vera was first analysed as a weak surface circulation 100 nm (185 km) south-east of Ponape on 27 October and was included on JTWC's Significant Tropical Weather Advisory for the next four days. Low-level inflow during this period was split between several weak eddies.

By 0000 on 30 October, synoptic data indicated that the low-level inflow was now concentrated into the developing cyclone. Meanwhile, the convective activity increased rapidly over a 24-hour period from 0000 on 31 October to 0000 on 1 November. A TCFA was issued at 0000 on 1 November on the basis of increased upper-level outflow and a continued decrease in surface pressure.

Aircraft reconnaissance at 2100 the same day found an ill-defined circulation centre with a central pressure of 1,004 mb and estimated surface winds of 15 kt (8 m/sec). Numbered warnings began at 0000 on 2 November on the basis of an improved satellite signature. Rapid intensification occurred, and TD 24 was upgraded to Tropical Storm Vera six hours later. Vera continued to intensify, reaching typhoon strength by 0000 on 3 November while 190 nm (352 km) SSE of Yap. At that time, the 200 mb analysis revealed that a large upper-level anticyclone, previously located north-west of Vera, was weakening and was no longer restricting Vera's outflow to the north. By 0000 on 2 November, the anticyclone situated over Vera had become the dominant upper-level synoptic feature over the western Pacific.

From the time of the first warning until her approach to the Philippines north-east of Samar, Vera moved on a virtually straight west-northwest track (see figure 17). The major influence on her movement was the unusually strong mid-tropospheric subtropical ridge over the western Pacific. The strength of the easterly current south of the ridge steered Vera at forward speeds of 20 to 22 kt (37 to 41 km/h) – almost twice the climatological average – as she passed 35 nm (65 km) south of Yap. As a result, although JTWC's forecast tracks were consistent and accurate, forecast forward speeds lagged behind Vera's actual speeds. The underestimates were considerable during the early stages of acceleration.

Vera continued to intensify during her WNW accceleration and reached super typhoon intensity only 18 hours after being upgraded to a typhoon. Reconnaissance aircraft reports indicated Vera maintained super typhoon strength for over 24 hours before weakening as she approached Catanduanes Island. The peak wind reported on Catanduanes Island was 50 kt (26 m/sec) at 1200 on 5 November as Vera passed just off the coast.

The island chain began restricting low-level inflow as Vera continued north-westward toward northern Luzon. Vera made landfall north of Tarigtig Point, packing winds of 90 kt (46 m/sec).

After landfall, the onset of enhanced low-level north-easterly flow over the Taiwan Straits, coupled with strong upper-level southwesterlies over the Philippines, resulted in vertical disorganization and rapid weakening of Vera. Radar and aircarft reports indicated the low-level circulation continued to track northwestward over the Cagayan River valley and exit into the South China Sea near Culili Point south of Laoag. The upper-level circulation sheared off near Tuguegarao and was tracked using satellite imagery northward over Aparri, then to the ENE into the Philippine Sea. Surface synoptic and ship reports at 0000 on 7 November indicated that a secondary surface centre existed near Baguio. At the same time, the primary centre was crossing the Cordillera Central Mountain range 95 nm (176 km) to the north.

After exiting into the South China Sea, the strong north-east monsoon flow accelerated Vera to the southwest, and the final warning was issued at 1200 on 7 November, downgrading Vera to a tropical depression.

L. TYPHOON ABBY

Abby, the last typhoon of the 1979 season, developed over the Marshall Islands during early December. Abby proved to be an unusual cylone in several ways. Throughout much of Typhoon Abby's existence, she was not vertically aligned. Aircraft reconnaissance located the mid-level circulation centre displaced as much as 55 mm (102 km) from the sur-

face centre. At one point, two centres were identified. In addition, Abby fluctuated between tropical depression and tropical storm strength several times before reaching typhoon strength 10 days after formation.

Within 24 hours of the first warning, aircraft reconnaissance observed surface winds of 45 kt (23 m/sec) and a sea-level pressure of 996 mb. The surface and 700-mb centres were displaced by 12 nm (22 km). Abby continued to intensify to 60 kt (31 m/sec) on 4 October while increasing the displacement between the surface and 700-mb centres.

Abby deviated from a westward track to a NNW track on 3 December with a reduced forward speed of movement. The temporary northward movement was associated with a deepening mid-tropospheric trough which moved rapidly north-eastward away from Japan on 1 December. Abby resumed a westward track with increased forward speed after the trough axis passed east of Abby late on 3 December.

All available information (climatology, analog aids, analyses and numerical forecasts) indicated continued intensification as Abby tracked towards Guam. This expected intensification was reflected in JTWC warnings during this period. However, the opposite occurred. As Abby moved west of Truk, she weakened to less than tropical storm strength. An uppor tropospheric anticyclone north of Abby restricted her outflow and resulted in the observed weakening. By 7 December, Abby reintensified to minimum tropical storm strength as she moved westward and away from the influence of the restricting anticyclone. Abby then tracked to the WNW under the influence of a mid-tropospheric longwave trough oriented along 142°E. As the trough moved east of Abby, the subtropical mid-tropospheric ridge again built eastward, providing a mechanism which steered Abby towards the WSW. During 8 December, Abby once again weakened to less than tropical storm strength and increased her forward speed of movement.

Abby was not vertically aligned from the issuance of the first warning through 9 December. On that day aircraft reconnaissance making a supplemental fix at 0617 observed that Abby possessed multiple 700 mb centres. By the time of entry into Abby for a levied 0830 fix, only one well-organized, intensifying centre was found. Satellite imagery at 0144 on 9 December indicated the possible existence of multiple outflow centres. While Abby was reorganizing into a single centre, she began to reintensify to tropical storm strength. By 10 December, Abby had attained typhoon strength, which made her the last typhoon of the decade (see figure 18).

A mid-tropospheric short-wave trough moved from China into the Sea of Japan and deepened on 10 December. In response to the short-wave trough, the subtropical mid-tropospheric ridge again receded eastward north of Abby. The interaction of these two synoptic features allowed Abby to track north-west again. On 11 December Typhoon Abby recurved in response to another mid-tropospheric short-wave trough which extended further south than the trough of the previous day. This last trough in the series moved into the northern part of the South China Sea and deepened, causing Abby to finally follow a recurvature track.

Typically, recurving typhoons have their maximum intensities either less than 12 hours after recurvature or prior to recurvature. Abby, however, did not reach maximum intensity until 36 hours after recurvature. By 13 December, Typhoon Abby reached maximum intensity of 110 kt (57 m/sec) with an MSLP of 951 mb. As Abby continued toward the ENE, she approached a regime of very strong westerlies in the middle and upper troposphere. The strong westerlies induced Abby's acceleration and rapid weakening. Abby dissipated on 14 December owing to strong vertical shear between the surface and middle levels.

M. TC 17-79

TC 17-79 was the only significant tropical cyclone in the Bay of Bengal during the 1979 spring transition season. Attaining typhoon intensity, TC 17-79 was the most destructive cyclone in India since TC 22-77 (November 1977), which, coincidentally, followed a similar track.

A TCFA and the first warning were precipitated by synoptic reports received from ships participating in the First GARP Global Experiment (FGGE). At 1200 on 6 May, these ships' observations defined a cyclonic circulation near 07°N, 88°E with reported surface pressures near 1,003 mb and wind speeds of 20-25 kt (10-12 m/sec). The first warning on TC 17-79 was issued at 1507 on 6 May.

From 0000 through 1200 on 6 May, a strong mid-tropospheric ridge extended westward along 15°N with south-east steering flow dominating TC 17-79's movement. During the same time period, a short-wave trough, evident at both middle and upper levels, was deepening over India. Interaction between this ridging and troughing resulted in a loss of definitive steering flow in the vicinity of TC 17-79, producing an erratic northern and then southern track. Also during this time, TC 16-79 located in the southern Indian Ocean about 750-800 nm (1,389-1,481 km) to the south-west, began tracking slowly to the south-east, possibly initiating a Fujiwhara-type interaction.

By 0000 on 8 May, a mid-level anticyclone had formed in the northern Bay of Bengal with an ENE steering flow over TC 17-79, resulting in a WSW forecast track. From 0000 on 8 May through 0000 on 9 May, while TC 17-79 intensified, the dominant steering flow

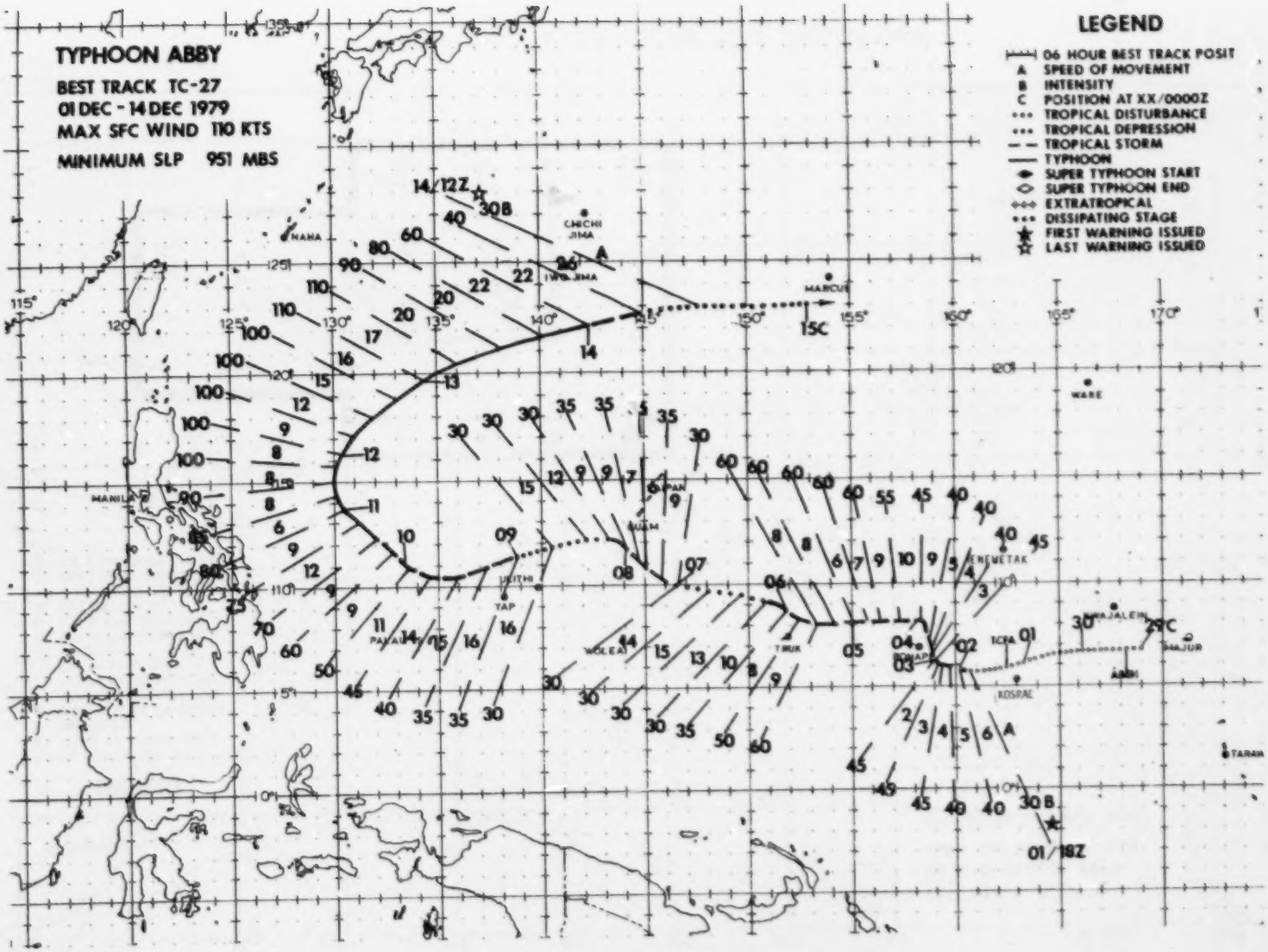


Figure 18. Typhoon Abby, best track

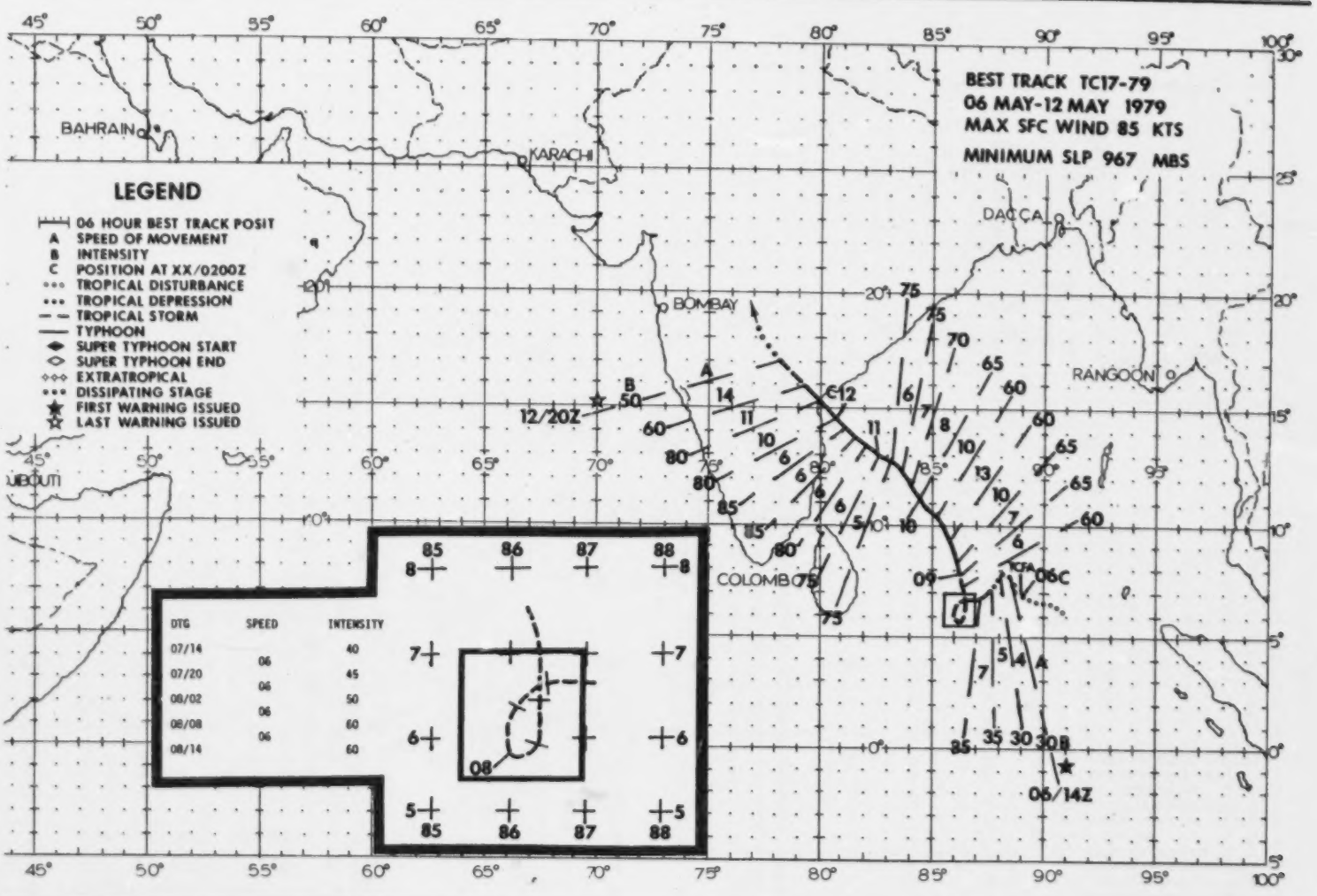


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Figure 19. Tropical cyclone TC 17-79 best track.

shifted to the south, then south-east as the mid-level ridge was replaced by a trough and the upper-level trough dug southward over India. As a result of this shift in steering flow, TC 17-79 executed a tight cyclonic loop from 0000 to 1800 on 8 May. From 7 through 9 May, although satellite fix position accuracies improved owing to the formation of a well-defined eye, forecast errors increased appreciably because of the erratic movement.

By 1200 on 9 May, south-east steering flow became dominant with TC 17-79 oscillating about a north-west track until making landfall over India (see figure 19). TC 17-79 struck the east central coast of India at 0800 on 12 May, 45 nm (83 km) north of Nellore with maximum sustained winds of 80 kt (41 m/sec). Twenty-one deaths occurred and over 800,000 persons were left homeless as a result of TC 17-79's passage over the Nellore district.

III. DAMAGE CAUSED BY TROPICAL CYCLONES, FLOODS AND DROUGHTS IN INDIVIDUAL COUNTRIES OR AREAS IN THE THE ESCAP REGION, 1979

A. AUSTRALIA[4]

1. Tropical cyclones

Tropical cyclone Peter, with its residual rain depression, was active in the Gulf of Carpentaria area at the beginning of January, causing record rains and widespread floods on the Cape York Peninsula. Two deaths resulted and damage between 1 and 4 January was estimated at $A 10 million.[5]

Cyclone Kerry, which formed to the north-east of Solomon Islands, crossed the North Queensland coast near Proserpine on 1 March. It subsequently moved out to sea and reintensified before finally dissipating near Shoalwater Bay. Most damage was confined to the area near Mackay, where there was extensive damage to pleasure craft moored in Mackay Harbour and to roads and bridges in and around Mackay. This cyclone was most unusual in that it maintained its tropical cyclone characteristics for nearly three weeks.

Cyclone Hazel formed off the north-west coast on 7 March. It moved westward and then southward down the west coast, finally moving inland near Hamelin Pool. A fishing vessel sank off Carnarvon on 13 March with the loss of 15 lives. Damage to plantations in the Carnarvon area was estimated at $A 2 to 3 million and damage to a salt works near Cape Cuvier estimated at $A 2 to 5 million. Other damage to property along the path of Hazel was estimated at more than $A 18 million.

2. Floods

In early January, extensive flooding occurred in many coastal streams on the Cape York Peninsula. Later in January and into February, there was extensive flooding of the coastal streams between Rockhampton and Cairns. The major flood on the Barron River caused extensive damage to agricultural property, roads and bridges in the Cairns area.

Further extensive flooding occurred in the Burdekin and Fitzroy River basins in Queensland during late February and early March owing to the effects of cyclone Kerry. Approximately $A 1 million damage was caused to a recently completed weir on the Burdekin River. Damage occurred to roads and bridges around Mackay.

Local flash flooding due to thunderstorm rains caused more than $A 1 million damage at Port Pirie in South Australia on 31 December.

3. Droughts

Severe rainfall deficiencies developed over much of the south-west of Western Australia during the winter and early spring. November rainfalls over much of this region were higher than normal, but the amounts were not sufficient to overcome the deficiencies.

In eastern Victoria, some southern and eastern parts of New South Wales and eastern Tasmania, serious rainfall deficiencies built up during winter and spring and continued into the summer.

4. Other severe weather events

On 7 November, a violent thunderstorm swept through Kalgoorlie in Western Australia and the surrounding area, resulting in extensive property damage. Kalgoorlie experienced a record wind gust of 139 km per hour.

Damaging thunderstorms in South Australia on 14 November were described as the most violent and widespread for many years, and resulted in damage estimated as high as $A 20 million. In the Barossa Valley, damage to some of the wineries alone has been estimated at $A 2 million. Severe structural damage occurred at Port Broughton, where 52 houses were destroyed and a further 300 damaged. A record wind gust for South Australia of 167 km/h occurred at Woomera during one of these thunderstorms.

On 15 November, thunderstorms over the south-western suburbs of Sydney caused considerable damage. At Bankstown Airport 10 aircraft were extensively damaged and a further 20 suffered some damage; one building was demolished and another damaged. A wind gust of 133 km/h during the storm was the highest ever recorded at Bankstown Airport.

On 13 December, severe thunderstorms over north-eastern New South Wales and south-eastern Queensland caused considerable damage. At Lismore, the worst affected centre, 40 to 50 houses were damaged and 23 people treated for lacerations.

B. BURMA

Details of damage caused by floods, drought and cyclones during 1979 are given in table 6.

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[4] *Source:* Government of Australia, Department of Science and the Environment, Bureau of Meteorology.

[5] $A 0.894 = $US 1.00 (1979 period average).

Table 6. Damage caused by floods, drought and cyclones in Burma, 1979

Area damaged by floods (ha)	*Area affected by drought (ha)*	*Cost of damage to roads, bridges and other structures from floods (Millions of US dollars)*	*Cost of damage to structures from cyclones (Millions of US dollars)*
160,623	1,411,996	1.68	1.62

Source: Director General, Department of Meteorology and Hydrology, Ministry of Transport and Communications, Government of Burma.

C. HONG KONG[6]

1. Droughts

The total rainfall in 1979 was 2,614.7 mm, which was 368.3 mm above normal. No water supply restrictions were imposed in Hong Kong during 1979.

October 1979 was the driest October on record with no rainfall at all registered at the Royal Observatory or at any of the other rainfall stations in Hong Kong. It was also the sunniest, least humid and least cloudy October on record. The last quarter of the year was sunny and very dry. The total rainfall was only 11.4 mm, which was the second lowest on record. Owing to the prolonged dry conditions (which continued through January 1980), numerous hill fires broke out and destroyed hundreds of thousands of trees, as shown in table 7.

Table 7. Grass and hill fires

	Jan.-Mar.	*Apr.-June*	*Jul.-Sept.*	*Oct.-Dec.*	*Total*
Number of grass or hill fires	105	33	Nil	727	865
Number of trees damaged/ destroyed within plantation/management areas	10,500	340	Nil	720,000	730,840

2. Heavy rain and floods

An intense cold front on 2 April 1979 brought heavy squally showers and thunderstorms to Hong Kong. A minor landslip occurred in Au Tau and flooding was reported in various parts of Hong Kong. Rainfall of 161 mm (more than half of the month's total) was recorded between 13 and 15 May, when a trough of low pressure was near Hong Kong. Flooding was reported in many places and several minor landslips occurred. In June the wettest period was between 7 and 11 June. On 11 June the rainfall amounted to 113.6 mm and resulted in three landslips. Two hundred people had to be evacuated from Wong Tai Sin. The heavy rain in the second quarter of 1979 caused serious fruit-drop of lychee and longan. Vegetable production was also below normal.

3. Tropical cyclones

There were 29 tropical cyclones over the western North Pacific and the South China Sea during 1979 and tropical cyclone warning signals were hoisted in Hong Kong for six of them. The hurricane signal, No. 10, was hoisted during the passage of Typhoon Hope on 2 August. Severe Tropical Storm Mac passed over western Lantau Island during the night of 23 September and brought gales to Hong Kong. The other four tropical cyclones only caused strong winds. The rainfall associated with these six tropical cyclones amounted to more than 1,000 mm, which represented nearly half of the summer rain in 1979. The occasions on which tropical cyclone warning signals were issued are described below.

(a) *Typhoon Ellis (1-6 July)*

Ellis formed about 1,080 km east of Manila early on 1 July and moved north-west towards northern Luzon. It passed through the Balintang Channel on the morning of 4 July and then moved towards the WNW while it weakened into a severe tropical storm. Ellis made its closest approach about 160 km SSW of Hong Kong around midnight on 5 July. The total rainfall brought by Ellis was only 13.2 mm. During the approach of the storm, two boats sank in Yau Ma Tei Typhoon Anchorage but damage to property in Hong Kong was minimal.

(b) *Severe Tropical Storm Gordon (26-30 July)*

Gordon developed about 1,030 km north-east of Manila. It landed near Shantou early on 29 July and weakened. Gordon was nearest to Hong Kong around 0200 on 29 July, when it was about 40 nautical miles (mm) to the north. Although there were only a few hours of strong winds off-shore, rainfall was very heavy. A total of 260.2 mm of rain was recorded. Many places in the New Territories were flooded and some minor landslips occurred. The worst occurred in Shatin, Sheung Shui and Kam Tin, where farmland was inundated.

(c) *Typhoon Hope (28 July-3 August)*

Typhoon Hope was the most severe typhoon to affect Hong Kong since Typhoon Rose in 1971. It passed over the New Territories from east to west on 2 August. Maximum gusts were generally about 100 knots all over Hong Kong. A maximum gust of 108 knots was recorded at Star Ferry Pier, Kowloon. This

[6] *Source:* Royal Observatory, Government of Hong Kong.

is the highest gust recorded inside Victoria Harbour since 1971. The instantaneous minimum mean sea-level pressure of 961.6 millibars at the Royal Observatory was the second lowest on record and the lowest in August. Fortunately, Hope was a fast-moving typhoon. Casualties and damage to property would have been more severe if Hope had moved more slowly during its passage. Twelve people were killed and 260 were injured, of whom 94 were hospitalized. About 2,000 people sought shelter in Government emergency centres. A total of 53 huts were destroyed and 796 people made homeless. At the height of the typhoon, 18 vessels broke away from their anchors and were adrift in the harbour. The Star Ferry Pier on Kowloon side was rammed by the Greek-registered 10,300 ton vessel, MV *Argonaut*. In Aberdeen, 11 boats sank and nine dwelling boats were seriously damaged. At least six pleasure craft moored at the Aberdeen Typhoon Anchorage were reported to have been seriously damaged. Another 10 boats sank in the Yau Ma Tei Typhoon Anchorage but there were no casualties. A tide gauge at Tai Po Kau indicated that the sea level rose abruptly from 0.9 metres at 1430 to a maximum of 4.3 metres at 1620 hours, causing serious flooding in Tin Sam Village near Lam Tsuen River in Tai Po, where three people were killed. Numerous landslips occurred on both sides of the harbour, but none were serious. When a dangerous goods storehouse in Yau Ma Tei was damaged by sea waves, 270 metal canisters containing a lethal cyanide salt were flung into the harbour.

A total of 287.4 mm of rain was recorded in Hong Kong during Typhoon Hope. The hurricane force wind and torrential rain caused farmers in the New Territories to suffer heavy losses, including more than 1,450 ha of vegetable and flower crops, 84,500 fruit trees and nearly 113,000 head of livestock, which were destroyed. As a result, rehabilitation grants from the Emergency Relief Fund amounting to $HK 2,395,709[7] were used to assist 11,034 farmers. About 140 large and small fishing vessels were damaged, and some 400 marine fish culture operators suffered losses amounting to some $HK 3.6 million. The flooding of some 50 ha of fish ponds resulted in an estimated loss of $HK 2 million. The Social Welfare Department handed out a total of 106,446 cooked meals to 846 victims from 160 families. Damage to public works amounted to $HK 8,956,780. Five submerged telephone cables under the harbour were damaged by ships dragging their anchors. There was widespread disruption of power supplies in the New Territories. Power failure was also reported in various districts of Hong Kong.

(d) *Tropical depressions (6-9 August)*

Two tropical depressions formed at about the same spot over the South China Sea on 6 August and 8 August north-east of Xisha Dao (Paracel Islands). Both tropical cyclones took a westerly track and had little effect on the weather in Hong Kong.

(e) *Severe Tropical Storm Mac and Tropical Storm Nancy (16-24 September)*

There have been very few occasions on which two tropical cyclones have been centred within 400 nautical miles of Hong Kong at the same time. On this occasion, the stand-by signal, No. 1, was hoisted for Tropical Storm Nancy but as Nancy moved away westwards across Hainam Dao (Hainan Island), Severe Tropical Storm Mac approached from the south-east and the stand-by signal therefore remained hoisted. Severe Tropical Storm Mac passed over western Lantau Island around midnight on 23 September. Apart from the urban areas, gales were experienced in many locations during 23 September. Nancy apart from bringing rain to Hong Kong, had little effect on the weather. However, Mac killed one person and injured 67. More than 300 people sought refuge in typhoon shelters. Owing to the 243.7 mm of rain brought by Mac on 23 September, many roads were flooded and several minor landslips occurred. Damaged to public works amounted to $HK 906,700. The Social Welfare Department handed out 7,908 meals to 133 victims from 57 families.

Remarks

This report has been compiled from information supplied by the Agriculture and Fisheries Department, Fire Services Department, Public Works Department, Social Services Department and Royal Observatory as well as from the press. It does not include damage to private property, which is seldom reported, nor has any attempt been made to estimate the number of working hours lost owing to bad weather.

D. INDIA[8]

1. Cyclonic storms

Six cyclonic storms were formed in the Indian seas during 1979, three in the Bay of Bengal and three in the Arabian Sea. The tracks of these storms are shown in figure 20. The most serious one was the hurricane which hit the south coast of Andhra Pradesh in May, causing considerable loss of life and damage to property. No serious damage was reported in association with the other cyclones. The details of the damage are given below.

(a) *Severe cyclonic storm, 5-13 May*

This system developed as a depression over the south-east Bay of Bengal on 5 May. Moving westward until 7 May and later south-westward, it became a severe storm by the morning of 8 May. Then it sharply

[7] $HK 5.00 = $US 1.00 (1 December 1979).

[8] *Source:* Meteorological Department and Central Water Commission, Government of India.

changed its course and moved towards the NNW and developed a core of hurricane winds by the morning of 11 May, when it was centred about 300 km east of Madras. Subsequently it moved to the north-west, crossed the coast near Ongole by the evening of 12 May, weakened progressively and dissipated over Telangana on 14 May. This was the first occasion during the last 100 years that a cyclonic storm formed at such a low latitude in the month of May.

In association with this cyclone, widespread rain with heavy to very heavy falls occurred in Andhra Pradesh between 12 and 14 May. Many stations in Prakasam district and a few stations in adjoining Nellore and Mahabubnagar districts recorded 200 to 400 mm of rain on 13 May. Gales with speeds reaching 100 to 160 km/h were reported in Nellore and Prakasam districts almost continuously from the morning until midnight on 12 May. It is reported that many trees were uprooted and electric posts were bent and twisted in Nellore and Prakasam districts, leading to disruption of road traffic and telecommunications, and extensive damage to power lines. Enormous damage was caused to railway property by the swollen rivers and heavy rain. Two bridges near Tanguturu (Prakasam district) were washed away. The cyclone affected 4 million people in Andhra Pradesh. Crops in 70,000 hectares and about 700,000 houses were damaged. About 700 human lives and 300,000 head of cattle were lost. The total damage to crops, houses and public utilities was about Rs 1,700 million.[9] Tidal waves which affected the coastal areas of Prakasam, Guntur and Krishna districts rose to 3 to 4 metres near Woolapalam and Pedaganjam, 3 metres near Suryalanka and 2 to 3 metres along the coast extending from Nizampatnam to Hamsaladivi.

Heavy rains and strong winds of 80 to 100 km/h also affected Madras City and Chingleput district. Gale force winds and high seas caused erosion at several places along and near the Madras coast, affecting a number of fishermen's villages. The Pulicat area (Chingleput district) was isolated by the rise in the backwaters. Power supply was disrupted in many areas in Madras City on 11 and 12 May.

(b) *Cyclonic storm, 16-20 June*

A depression formed over the east-central Arabian Sea off the Karnataka coast on the morning of 16 June with its centre near 13.5°N, 70.5°E. The depression moved north-westward until the evening of 17 June and intensified into a cyclonic storm on the morning of 18 June, when it was centred near 18°N, 65.5°E. Thereafter, it moved westward to the Arabian coast by 20 June. This system caused the advance of the south-west monsoon into most parts of Karnataka, Goa and into south Konkan between 16 and 18 June with some very heavy rainfall in coastal Karnataka. No damage was reported in association with this system.

(c) *Severe cyclonic storm, 6-7 August*

The remnants of Typhoon Hope moved westward across Burma into the north-east Bay of Bengal on 5 August as a well-marked low. This low concentrated into a depression on 6 August over the north Bay. Continuing to move in a westerly direction, it intensified into a severe cyclonic storm by the afternoon of 7 August and crossed the coast near Balasore the same night. Subsequently, it weakened into a low over north Gujarat and adjoining south Rajasthan on 11 August. No serious damage was caused by this cyclone.

(d) *Severe cyclonic storm, 18-24 September*

A depression formed off the northern Kerala and Karnataka coasts on the morning of 18 September with its centre near 12°N, 73°E. Moving in a north-westerly direction, it intensified into a severe cyclonic storm on the afternoon of 22 September over the northern central Arabian Sea. Thereafter, it moved westwards, gradually weakened and crossed the Arabian coast south of Masirah as a depression by the night of 24 September. No damage was reported in association with this system.

(e) *Cyclonic storm, 13-17 November*

This system developed as a depression on the morning of 13 November with its centre near 9.5°N, 71.5°E over the south-east Arabian Sea and adjoining Lakshadweep. Moving initially north-west and later NNE, it intensified into a cyclonic storm on the evening of 15 November with its centre near 15°N, 70°E. It again changed its course to the north-west after 16 November and dissipated off the Saurashtra coast on 18 November. No damage was caused by this cyclone.

(f) *Cyclonic storm, 23-25 November*

A depression formed over the southern Bay of Bengal on the morning of 23 November with its centre near 8.5°N, 87.5°E. Moving in a north-westerly direction, it intensified into a cyclonic storm the next morning with its centre near 11°N, 84°E. It crossed the coast near Sriharikota on the afternoon of 25 November and rapidly weakened into a low over Rayalassema by the morning of 26 November. No damage was reported in association with this storm.

2. Flood situation in India during 1979, by state

The south-west monsoon first advanced into the Andaman Sea and south-east Bay of Bengal towards the last week of May. By the second week of June, the monsoon broke over Kerala and Assam and covered North Maharashtra, Andhra Pradesh, east Madhya Pradesh, Orissa, Gujarat and West Bengal by 21 June.

[9] Rs 8.126 = $US 1.00 (1979 period average).

By 1 July it had covered south-east Rajasthan and parts of Uttar Pradesh. By 4 July the monsoon had covered almost the entire country.

The total rainfall to the end of October was below normal over large parts of the country, including the Andaman and Nicobar Islands, sub-Himalayan West Bengal, Bihar Plateau, Uttar Pradesh, Haryana, Chandigarh and Delhi, Punjab, Himachal Pradesh, Jammu and Kashmir, east Rajasthan, Madhya Pradesh, Gujarat, Daman, Dadra and Nagar Haveli, Konkan and Goa, coastal Andhra Pradesh and Telangana, creating near-drought conditions. However, cyclonic storms accompanied by heavy rains/flash floods caused considerable damage in parts of coastal Andhra Pradesh, Gujarat, Rajasthan and Tamil Nadu. Parts of Uttar Pradesh and north Bihar were also subjected to floods, causing sizable damage.

A severe cyclone hit the Andhra Pradesh coast on 12 May and caused heavy damage in the coastal districts. Unprecedented rains during 15-20 July affected parts of as many as 10 districts in Rajasthan and disrupted road and rail communications. Owing to unprecedented rainfall in Rajkot (Gujarat) on 11 August and consequent floods in the Machhu River, the Machhu-II Dam overtopped and the earthen flanks breached, causing havoc in Morvi and Malia *talukas*, taking a heavy toll of human lives. Widespread rainfall in November in Tamil Nadu caused heavy damages to roads, irrigation works and tanks, with extensive damage in the districts of Tirunelveli, Kanyakumari, Madurai and Ramanathapuram. Parts of Assam, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab and West Bengal were also affected by floods.

On account of the generally deficient rainfall in most parts of the country, the incidence of floods and flood damage was much below average. Important features of the flood situation in the various states during the year are outlined below.

Andhra Pradesh

The severe cyclone which hit the coast on 12 May caused considerable loss of life and property in the coastal districts. Ten districts were seriously affected. Following heavy rainfall, the Godavari River was in low floods at Dowlaiswaram during 5-7 August. Low-lying areas in Bhadrachalam of Khammam district were inundated.

Assam

The Brahmaputra Valley in Assam experienced four flood waves during the 1979 monsoon season: from 27 June to 5 July; from 5 July to 11 August; from 20 August to 21 September; and from 3 October. The Brahmaputra all along its course and its main tributaries crossed the danger levels at various places. During the first wave, low-lying areas in the Brahmaputra Valley were inundated causing damage to standing *ahu* and jute crops. The Dhansiri River (north) changed its course in Mangaldoi subdivision of Darrang district on the north bank, flooding many villages. The north trunk road and the railway bridge between Rowta and Udalguri were damaged, disrupting communication. River embankments breached at 15 places. The Subansiri eroded its banks at Badatighat in North Lakhimpur subdivision and was changing its course. About 12 metres of railway line were damaged west of the Jiabhoroli River in Tespur subdivision of Darrang district, temporarily disrupting rail communications.

During the second wave, floods in the Dhansiri River (south) caused two breaches in a road. Four villages in Sibsagar district were affected by erosion of the river. Majuli Island was also subjected to erosion at several places. In Mangaldoi subdivision of Darrang district, a small local river, Kulsik, eroded homestead lands in five villages in Pamari gram panchayat. During the third wave, parts of Nowgong subdivision in Nowgong district were affected.

During the fourth wave of floods, the levels attained in the upper valley at Dibrugarh and Neamatighat were the highest in the season; the maximum level attained at Dibrugarh was 105.46 metres on 7 October. The floods caused considerable distress all along its course, particularly in Dibrugarh and Sibsagar districts. Rescue and relief measures were taken by the State Government, and assistance of the Army was requisitioned.

In Barak basin, the Barak River and its tributaries were in medium floods during July-August. The Longai River crossed the danger level, breached an embankment and inundated low-lying areas between Ramakrishna Nagar and Patharkandi. The Barak and its tributaries, the Sonai and Rukni, were again in floods in the second week of September and crossed the danger levels. The floods affected parts of 12 subdivisions in the Brahmaputra basin and parts of Cachhar district in the Barak Valley.

Bihar

The rivers Gandak, Burhi Gandak, Bagmati, Kamla Balan, Kosi, Adhwara and Mahananda in north Bihar, and the Sone and Punpun in the south were in medium floods from 17 July to 13 August and crossed the danger levels at several places. Almost all the north Bihar rivers were again in floods on 21 August and crossed the danger levels. The floods subsided in the third week of September. The floods affected all 13 districts in the State.

Gujarat

Floods of the Luni River from Rajasthan entered Gujarat, affecting parts of Banaskantha district on 20

July. Several villages were affected and about 150 persons were stranded and later rescued. About 50 houses were either destroyed or damaged. The River Narmada was in floods and recorded a level of 9.6 metres at Golden Bridge, Bharuch (against the danger level of 6.71 metres) on 11 August. The floods receded below the danger level on 14 August. Low-lying areas in Bharuch were submerged, and army boats were pressed into service for rescue and relief operations.

Heavy rains occurred in Rajkot district on 11 August and lashed Morvi and Malia *talukas*. As a result of this unprecedented rainfall in the catchment and consequent floods in the river, the Machhu-II dam (a medium irrigation project) near Morvi overtopped. The earthen flanks on the right and left of the masonry structure breached in a length of 365.8 metres and 762.0 metres respectively. The masonry part was reported to be safe. Against the designed maximum flood discharge of about 5,663 m^3/sec, about 10,619 m^3/sec were reported to have passed over the dam. Owing to heavy rainfall, all the small rivers were in floods on 17 August, causing damage to certain minor irrigation works. Most of the reservoirs were filled to the designed capacity. Reservoirs critically located were depleted to meet with exigencies arising on account of continuous rains. Certain minor irrigation tanks breached. Following rainfall in its catchment, the Tapi River was above the danger level at Ukai from 17 to 24 September.

Haryana

In Karnal district, a breach occurred on the Chutang embankment and inundated paddy lands east of Karnal town. The breach was plugged.

A bridge under construction on the Morwana-Kurukshetra branch line of the northern railway was damaged by a sudden rush of flood water on 22-23 July.

Himachal Pradesh

Rains/floods affected parts of Hamirpur, Kinnaur and Mandi districts.

Karnataka

North and South Kanara districts experienced heavy rains on 7 August. Rains during the period from 11 June to 12 September affected houses, roads and irrigation works in the State. The River Ghataprabha was in floods and the bridge near Gokak was submerged by flood water on 12 August.

Kerala

Heavy rains/floods affected parts of 11 districts in the State.

Madhya Pradesh

The Indravati River rose in floods on 26 June and again on 9 July and overflowed the road bridge connecting Raipur and Visakhapatnam, disrupting communications. The Narmada River was in floods on 9 and 10 August. Road communication between Nagpur and Jabalpur was disrupted. The Tapi River at Burhampur crossed the danger level on 9 August and was flowing 1.5 metres above the danger level.

Maharashtra

The River Wunna was in flash floods on 7 August. In mid-August, heavy rains/floods affected parts of eight districts in the Vidharba area of the State.

Orissa

A strong cyclonic wind accompanied by heavy rainfall on 7 and 8 August affected the coastal belt of the State, covering parts of Cuttack, Puri and Balasore districts. Paddy fields were submerged owing to heavy rains. There were breaches in test relief embankments. Telephone and electricity lines were cut off and road communications were disrupted at some places. The floods in Jalaka and Baitarni rivers submerged low-lying areas of Nilgiri, Balasore and Bhadrak subdivisions of Balasore district. Eight persons were reported missing while fishing near the mouth of the Kansbans River.

Punjab

A heavy storm on 25 May damaged fruit gardens and stacked wheat awaiting threashing in Patti subdivision of Amritsar district. Owing to heavy rainfall in Balachaur area in Hoshiarpur district on 24 July, breaches occurred in Nallah bunds near Rail and Balachaur villages.

A hail storm occurred on 11-13 September, which affected eight villages in Faridkot district, two villages in Ferozepur district and seven in Gurdaspur district. Cotton, paddy and fodder crops were damaged.

Rajasthan

The River Chambal crossed the danger level at Dholpur on 16 July. Unprecedented heavy rains during 15-20 July affected parts of 11 districts, of which Pali was the worst hit. Owing to heavy damages to many roads, bridges and culverts, communications to several towns and villages were cut off.

Owing to heavy rainfall of 300 mm in 24 hours and overtopping of streams around Ajmer, the railway track between Ajmer and Beawar on the Delhi-Ahmedabad main line and the Ajmer-Nasirabad branch line breached on 15-16 July. Several rivulets in Ajmer district were in floods, causing widespread inundation in the district. The Luni basin in Rajasthan received very heavy rainfall. Pali recorded a total precipitation of

650 mm during the five day period, 15-19 July. Extensive areas in the districts of Pali, Jodhpur and Barmer were inundated. In Pali district 530 mm of rainfall was recorded in two days. In Barmer district, Balotra and adjacent areas of Barmer were marooned owing to heavy rains. Luni railway yard was submerged under 0.6 metres of water and there were 1.5 metres of water in the railway quarters. The flood waters of the Luni moved on towards Jalore district adjoining Gujarat. The railway staff at Luni were marooned and rescued with the help of the civil and army authorities.

Jodhpur City was cut off. The power supply to Jodhpur City was disrupted and several towns and villages in Jodhpur district were marooned. Rail communications were dislocated. The damage to the railways indicate that 13 sections were affected by heavy rains. Between Luni and Marwar Junction, a major bridge was submerged and the flood water flowed over it for about two days. The floods resulted in heavy loss of life and property. Army boats and Air Force helicopters were used for relief and rescue operations.

Tamil Nadu

Consequent to the cyclone in the second week of May, backwaters of Pulicat area of Changlapattu district bordering Andhra Pradesh and low-lying coastal areas of Madras City were inundated. Following a depression in the Bay of Bengal, widespread rainfall occurred throughout the State in November, with intense rainfall in the districts of Tirunelveli, Kanyakumari, Madurai and Ramanathapuram. As a result of heavy rainfall, most of the reservoirs filled up rapidly. Many rivers rose in floods. Several tanks filled and breached, causing widespread damage and loss of life and property. Numerous irrigation channels overflowed their banks and breached. Irrigation systems were badly affected. Road communications suffered extensive damage. Rail communications were disrupted in many places for a number of days. The railway track breached in several places and water overflowed the bridge at Paramakudi. Land slides occurred in many places in Nilgiris district. The heavy rains/floods affected as many as 16 districts in the State, causing considerable loss of life and damage to property.

Tripura

Heavy rains from 30 June to 5 July affected parts of Dharamanagar and Kailashahr subdivisions in North district. The Manu River crossed the danger level at Kailashahr. Floods in the Juri River inundated low-lying areas in Dharamanagar.

Following rainfall in their catchments, the rivers Khowai, Manu, Gumti and Muhuri rose in floods and crossed the danger levels on 27 August. The rivers Dholai Khowai and Manu were again in floods and crossed the danger levels on 11 September. A portion of the Babugram embankment was washed away.

Uttar Pradesh

Following the rise in the water level of the rivers Ghaghra and Girwa, two pontoon bridges, one on the Ghaghra River and the other on the Girwa River, were washed away in the third week of May. The Ganga, the Ghaghra and the Sarda were in low to medium floods from 15 July to 25 August. The flow of the River Bhagirathi was reported to have diverted itself into the inlet channel of the Manari-Bhalli hydroelectric project (under construction) in Uttar Kashi district. Following rainfall from 14 to 19 Ausut, landslides occurred in the districts of Pithoragarh, Almora and Chamoli. In Nainital, heavy rains caused floods in the rivers Sukhi and Baigul; part of Sitarganj town were submerged.

West Bengal

The north Bengal rivers, Teesta, Jaldhaka and Torsa, were in low to medium floods in the third week of July, fourth week of August and second week of September. The rivers Bansloi, Ajoi, Damodar, Mundeswari and Kaliaghat in south Bengal were also in floods in the fourth week of July. The River Ganga crossed the danger level at Farakka on 13 July. Floods in almost all the rivers in north and south Bengal receded by mid-September. The River Bansloi was again in floods in the first week of October and crossed the danger level at Railway Bridge.

As a result of heavy and incessant rainfall from 23 July, floods of varying intensity occurred in the districts of Jalpaiguri, Cooch Behar, West Dinajpur, Darjeeling and Malda. In Jalpaiguri district, Mekhligang town protection embankments, Nelapakri embankment and Bakali embankments were affected by Teesta floods. Low-lying areas in PS Mal were inundated and 300 families affected. The right side and protection works of river Mahanadi in Islampur subdivision of Malda district breached, forming a spill channel. Some areas in PS Gangarampur and PS Tapan were inundated on 27 July and 9 September owing to spilling of the River Punarbhaba.

As a result of a depression in the Bay of Bengal, some areas in the coastal districts of 24 Parganas and Mindapore were lashed by a cyclonic storm between 6 and 8 August. Breaches occurred in embankments in some areas due to overtopping.

3. Flood situation in Union Territories

Arunachal Pradesh

The rivers Siang and Lohit were in low floods in the third week of July. There was continuous rainfall from 28 to 30 June in the catchment areas of the rivers Tonga and Bichom in Kamong district. The River Tonga changed its course, and a bridge was washed away. Communication between Tezpur and Bomdilla was completely cut off.

Table 8. Statement of flood damage in India, by state, 1979

Sate	*Area affected*	*Population affected*	*Damage to crops*		*Damage to houses*		*Cattle lost*	*Human lives lost*	*Damage to public utilities*	*Total damage to crops, houses and public utilities*
			Area	*Value*		*Value*				
	(1,000 ha)	*(1,000)*	*(1,000 ha)*	*(Millions of rupees)*	*(Number)*	*(Millions of rupees)*	*(Head)*	*(Number)*	*(Millions of) rupees)*	*(Millions of rupees)*
Andhra Pradesh	73	4,000	73	216.4	737,500	1,200.0	301,180	706	268.0	1,684.4
Assam	658	1,876	163	4.4	13,307	–	6,817	26	105.7	110.1
Bihar	806	3,738	274	190.2	27,816	10.3	4	14	1.4	201.9
Gujarat	475	3,046	475	165.5	143,358	248.9	189,878	2,005	1,041.7	1,456.1
Haryana	8	–	2	0.1	151	...	–	–	–	0.1
Himachal Pradesh	–	2	–	0.1	304	0.5	27	5	–	0.6
Karnataka	–	–	–	1.5	87	0.2	–	–	25.9	27.6
Kerala	205	610	102	2.2	53,293	3.1	216	37	7.8	13.1
Madhya Pradesh	–	10	–	0.2	61	0.1	3	9	0.1	0.4
Maharashtra	106	93	106	50.4	62,850	29.0	3,065	51	5.8	85.2
Orissa	301	1,558	184	5.0	1,939	0.9	85	16	46.4	52.3
Punjab	2	5	2	4.4	–	–	–	–	–	4.4
Rajasthan	565	1,121	175	236.3	93,620	470.0	113,842	478	299.4	1,005.7
Tamil Nadu	39	4	37	48.4	160,829	113.5	3,664	209	631.9	793.8
Tripura	–	...	–	...	...	...	...	...	...	...
Uttar Pradesh	703	2,105	518	517.7	22,958	17.2	222	77	...	534.9
West Bengal	21	146	...	...	1,051	...	...	1	0.1	0.1
Arunachal Pradesh	–	–	–	–	–	–	–	–	–	–
Delhi	...	...	...	...	...	...	...	...	...	...
Total	3,962	18,314	2,111	1,442.8	1,319,124	2,093.7	619,003	3,634	2,434.2	5,970.7

Source: Central Water Commission, Government of India.

Note: Rs 8.126 = $US 1.00 (1979 period average).

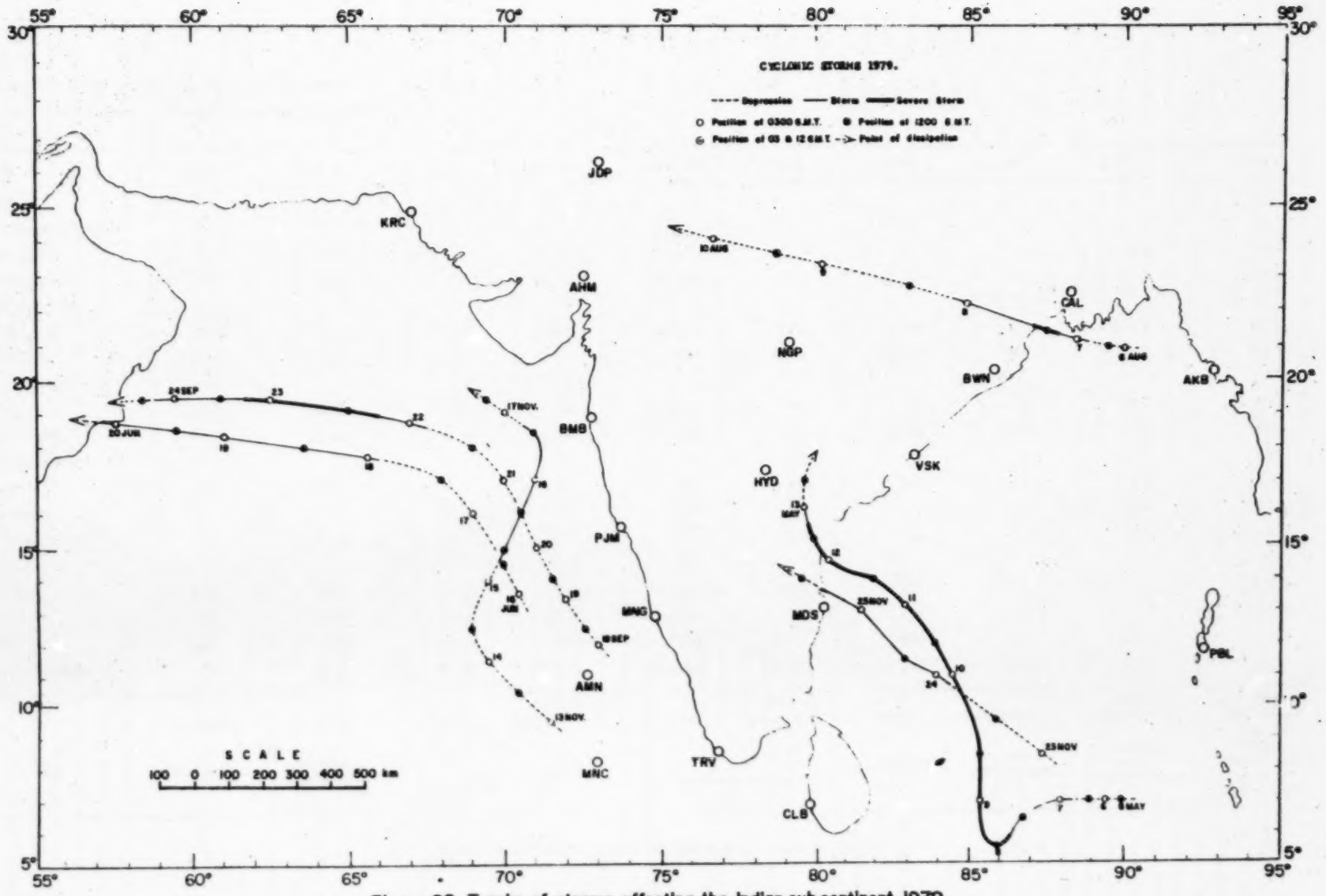

Figure 20. Tracks of storms affecting the Indian sub continent, 1979

Table 9. Statement of damages caused by floods and other natural disasters in Indonesia in 1979

Date	Hazard	Location		Casualties		Property			Remarks
		Province/region	City/district	Dead	Injured	Houses	Farmland (ha)	Cattle	
19 January	Floods	Jakarta	Jakarta	20	-	-	-	-	One third of Jakarta was flooded.
2 February	Floods	South Sumatra	Lahat	72	-	-	1,310	-	"
16 February	Floods	South Kalimantan	Hulu Sungai Utara	2	-	-	35,000	-	"
20 February	Explosion of poison gases	Central Java	Mount of Dieng	130	-	-	-	-	"
26 February	Strong winds	West Java	Cirebon	-	-	116	-	-	"
27 February	Flood and landslides	East Nusatenggara	Larantuka (Flores)	141	-	538	1,670	-	Caused by heavy rainfall upstream.
18 March	Floods	North Sulawesi	Poigar	-	-	134	-	-	"
31 March	Floods	West Sumatra	Solok (Panitjauan and Solit Air)	2	3	55	221	3	"
28 April	Earthquake	North Sumatra	Sibolga	-	-	[illegible]	-	-	"
	Floods	West Java	Bogor	-	-	33	6	-	"
30 April	Floods	West Sumatra	Tanah Datar, Agam	97	46	354	700	18	"
22 May	Earthquake	West Nusatenggara	Ampenan (Lombok)	-	-	50	-	-	"
23 May	Floods	Central Java	Wanareja (Cilacap)	23	-	-	580	-	"
26 May	Earthquake	West Nusatenggara	Lombok, Tanjung	26	31	1,656	-	-	"
5 June	Heavy rainfall and strong winds	West Java	Banjar	-	-	-	-	-	1,000 rubber trees were uprooted.
13 June	Floods	East Kalimantan	Damai	13	-	-	-	-	Most of the dwellings were flooded.
18 July	Tsunami	East Nusatenggara	Lombien Island (south coast)	539	-	-	-	-	Losses estimated at Rp 166 million.
6 August	Floods	South Lampung	Wonosobo	-	-	107	Hundreds	615	Sheeps and hens.
3 September	Earthquake	Irian Jaya	Anaus (Japen)	13	-	-	-	-	50 per cent of dwellings sank into the sea.
8 October	Drought	East Kalimantan	Muarajawa (Samarinda)	-	-	-	-	-	Loss of 3,000 fruit and coffee trees.
20 October	Earthquake	Bali and Lombok	Bali and Lombok	1	-	2,000	-	-	"
23 October	Strong winds and heavy rainfall	Central Java	Sragen	2	-	266	-	3	"
29 October	Strong winds	Central Java	Solo and Boyolali	-	-	96	-	-	"
2 November	Earthquake	West Java	Tasikmalaya, Garut, Bandung and Ciamis	29	184	2,166	-	-	"
7 November	Strong winds	West Nusatenggara	Bima	-	-	142	-	-	Losses estimated at Rp 14 million.
13 November	Floods	East Sumatra	Deli Serdang	3	-	-	972	-	"
29 November-2 December	Floods	West Sumatra	Pesisir Selatan	-	-	3	-	-	"
1 December	Strong winds and heavy rainfall	West Java	Karawang	1	2	394	-	-	"
7 December	Floods	North Sumatra	Pakar Jae and Sarulla	9	33	126	250	-	"
14 December	Strong winds and heavy rainfall	Jogjakarta	Megawo	-	-	32	-	-	900 trees uprooted.
15 December	Earthquake	Bengkulu	Rejang Lebong	7	625	3,500	-	-	Losses estimated at Rp 4,600 million.
18 December	Earthquake	Bali and Lombok	Bali and Lombok	23	162	Hundreds	-	-	Losses estimated at Rp 11,000 million.
			Total	1,154	1,086	12,000 (approximately)	31,000	639	

Source: Climatological Division, Meteorological and Geophysical Institute, Government of Indonesia.
Note: Rupiah 623.05 = $US 1.00 (1979 period average).

Delhi

The river Uamuna was in low floods at the Delhi railway bridge on 23 July. Some low-lying riverine villages were affected.

4. Flood damage

Assessment of damage reported by the State Governments/Union Territories indicates that an area of almost 4 million ha and a population of 18.3 million were affected. Crops over an area of 2 million ha, valued at Rs 1,443 million, 1.3 million houses valued at Rs 2,094 million and public utilities worth Rs 2,434 million were damaged. Over 3,600 human lives were lost and 620,000 head of livestock perished. The total damage to crops, houses and public utilities in the country as a whole has been assessed at Rs 5,971 million.

Details of flood damage are given in table 8.

E. INDONESIA

Details of damage caused by floods and other natural disasters during 1979 are given in table 9.

F. IRAN[10]

During the period from 22 September 1979 to mid-January 1980 the amounts of rainfall reported from the north-western areas including west and east Azarbaijan and north Kurdistan provinces and the eastern parts of the country, including southern Khorasan Province and northern Sistan and Baluchestan were lower than the average over the past 15 years, notwithstanding severe precipitation all over country.

Compared with the average level of rainfall over the past 15 years, the mean precipitation in some areas was only 47 per cent of normal. Amounts of rainfall in other parts of country were more than 100 per cent, and in some parts even 200 per cent, of normal.

The mean temperature in the first half of winter was slightly higher than the average over the past 15 years. However, it gradually decreased so that in some western areas, the temperature was 4°C lower than the mean temperature of the past 15 years.

The low mean temperature in the winter caused snowfall in the north-eastern, north-western and central areas of the country. Heavy snow was considerable; during one 24-hour period Shahre-Kord was covered by 700 mm deep snow.

Areas in the south and south-east had severe rains, causing floods in Khuzestan and Lurestan provinces, resulting in property damage and loss of life. Meanwhile, temperatures in the south-western part of Iran, including the coastal provinces of the Oman Sea and the Baluchestan area, had been a little higher than the average of the last 15 years.

G. JAPAN[11]

1. Tropical cyclones

The tropical cyclones that caused much damage in Japan in 1979 were: Tropical Storm Ken, which hit the south-east of Kyushu on 2 September and passed through Shikoku and the Chugoku and Tohoku districts; Typhoon Owen, which landed in Shikoku on 30 September and passed through Kinki, Chubu and Tohoku districts; and Typhoon Tip, which hit the Kii Peninsula on 19 October and penetrated the Chubu and Tohoku districts and Hokkaido.

The three tropical cyclones resulted in 131 people dead or missing, about 95,000 houses inundated and about 40,000 ha of cultivated fields damaged. The losses totalled about 300,000 million yen.[12] The details of the damage are shown in table 10 and discussed below.

(a) *Tropical Storm Ken*

The tropical storm travelled over waters east of Nansei-shoto Islands, struck land around Tsubushi Town in Kagoshima Prefecture to move to the Sea of Japan through Shikoku and the Chugoku district, and re-landed in the Tohoku district to acquire extra-tropical characteristics. Although the cyclone was of small scale, 11 spouts occurred and caused damage in Kyushu, Shikoku and the Tokai and Kanto districts. Heavy rains associated with the typhoon amounted to more than 200 mm in the east of Kyushu, Shikoku, the south of the Kii Peninsula and the Chubu and San-in districts, in particular 452 mm at Miyakawa in Mie Prefecture. The maximum wind speeds of about 20 m/sec and the peak gusts of about 35 m/sec were registered in the east of Kyushu, Shikoku and Hokuriku district.

(b) *Typhoon Owen*

As the typhoon continued north with speeds of about 10 km/h over areas east of Okinawa-shoto and Amami-shoto Islands from the morning of 26 September to 29 September, the islands registered rainfall totals of 600 to 750 mm for the period of two days and nights. Koniya in Amamioshima Island received 758 mm rainfall.

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[10] *Source:* Iranian Meteorological Organization, Ministry of Roads, Iran.

[11] *Source:* Japan Meteorological Agency.

[12] Yen 219.17 = $US 1.00 (1979 period average).

Table 10. Damage from tropical storms, typhoons and heavy rainfall in Japan, 1979

	Tropical Storm Ken (3-6 September)	*Typhoon Owen (29 September-3 October)*	*Typhoon Tip (14-22 October)*	*Heavy rainfall (26 June-3 July)*	*Total*
Casualities (number)					
Dead and missing	6	14	111	27	158
Injured	26	83	478	49	636
Houses (number)					
Destroyed	7	29	101	72	209
Damaged	603	945	7,404	195	9,147
Inundated	2,864	54,696	37,721	47,497	142,778
Cultivated lands submerged (ha)	1,074	2,550	38,038	32,693	74,355
Roads damaged (sites)	299	576	3,923	2,094	6,892
Bridges washed away (number)	9	42	214	49	314
Railways disrupted (sites)	13	13	8	3	37
Landslides (places)	35	231	1,253	1,488	3,007
Embankments breached (sites)	4	276	1,465	386	2,131
Communication facilities disrupted (circuits)	–	55	1,604	–	1,659
Ships and boats sunk (number)	26	67	91	–	184
Total value of damages (millions of yen)	14,858	114,896	193,941	118,039	441,734

Source: Japan Meteorological Agency.

Note: Yen 219.17 = $US 1.00 (1979 period average).

The typhoon proceeded to the north-east with increasing speed, landed around Muroto City in Kochi Prefecture on the evening of 30 September to shift to the Pacific through the Kinki, Chubu and Tohoku districts and weakened, acquiring extratropical characteristics around Nemuro City in Hokkaido. A one-hour rainfall of 110 mm was measured at Nadan on Awajishima Island. Heavy rainfall for a few hours and peak gusts of about 40 m/sec were observed in Shikoku and the Kinki district.

Because of the typhoon and the accompanying front that moved northwards from areas south of Japan with developing activity, totals of 300 to 500 mm intermittently fell in the east of Kyushu, Shikoku and the Kii Peninsula from 24 September to 1 October.

(c) *Typhoon Tip*

The typhoon moved to the north-east over waters east of the Okinawa-shoto Islands on 18 October, hitting land around Shirahama Town in Wakayama Prefecture on the morning of 19 September. After that, the typhoon followed almost the same track as Typhoon Owen, that is, from the Chubu district to the east of Hokkaido through the Tohoku district, with increasing speed to move north-eastwards to the south of the Okhotsk Sea. The large-scale typhoon brought heavy rains of more than 400 mm to the Okinawa-shoto Islands, Kyushu, Shikoku, the Kii Peninsula and the Tokai district, including 967 mm in Hachiman-toge in Mie Prefecture from 17 to 20 October. During the passage of the typhoon, Honkawane in Shizuoka Prefecture had a one-hour rainfall of 79 mm and Miyakawa in Mie Prefecture a three-hour rainfall of 190 mm.

In comparison with Owen as an ordinary typhoon which caused much damage in the central part of the typhoon, Tip was accompanied by very strong winds over extensive areas, bringing about damage even in areas far away from the centre of the typhoon. Sixty-seven people were dead or missing from shipwrecks in the seas adjacent to Hokkaido.

2. Heavy rains due to the Baiu front

Heavy rains due to the stationary Baiu (monsoon) front, extending from Kyushu to Honshu through Shikoku, intermittently fell in western Japan from 26 June to 2 July. Rainfall totals were over 550 mm in Kyushu, Shikoku and the Chugoku and Kinki districts, particularly 1,281 mm in Shakadake in Ohoita Prefecture and 1,168 mm at Ebino in Miyazaki Prefecture. Overflows and landslides resulted in 27 persons dead or missing.

3. Droughts

No serious droughts were recorded in 1979.

H. MALAYSIA[13]

A review of flood and drought in Malaysia by state for the period 1 January to 31 December 1979 is given below.

1. Peninsular Malaysia

Perlis

There was no report of either flood or drought in the State during the year.

Kedah

Heavy rainfall of approximately 145 mm was recorded at Pedu Dam, Padang Sanai and Kuala Nerang from 10 to 13 November, which caused local flooding in the Kuala Nerang and Kuala Pai areas of Padang Terap District for about 48 hours. The water level of Sungei (Sg.) Padang Terap at Kuala Nerang was 0.9 m above danger level, while at Kuala Pai it was 1.2 m above danger level. The bridge at Kuala Nerang was under 1.8 m of water. Villagers from 22 families at Kuala Pai were evacuated to Kuala Pai Relief Centre. The water from this area also caused flooding in Kota Setar district from 12 to 14 November. About eight villages of Kota Setar district were under 0.3 m to 0.8 m of water. However, in December the weather improved and was generally sunny.

There was a drought period from January to March 1979. The rainfall averaged 28.9 mm per month during that period. About 20,000 people from seven villages in north Kedah experienced the effects. The off-season crop could be planted on schedule between February and March for 74,900 ha in Kedah because of the release of irrigation water from Pedu Dam. The damages due to flood and drought in monetary terms were not estimated.

Pulau Pinang

The year 1979 was a relatively dry one, registering an average rainfall of 2,217 mm. The early dry season commenced in December 1978 and continued into the months of January, February and March 1979. There were occasions of short duration of heavy rainfall during the months of September, October and November. Minor flooding occurred in town areas of Georgetown and also low-lying areas in the districts of Butterworth and Bukit Mertajam. No flooding occurred in the Sg. Muda River system. On the whole, minor flooding of two to three days duration was a nuisance, but caused no damage to crops or property.

No severe drought occurred in the State and no losses were reported. However, planting of the dry season paddy crop was delayed for four months.

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[13] *Source:* Office of the Director-General, Drainage and Irrigation Department, Ministry of Agriculture, Malaysia.

Perak

A minor flood occurred at the upper catchment of the Perak River on 27 November. Flood waters rose 0.6 m to 1.5 m above road level at certain locations along the main road. The main road between Grik and Kroh was cut off for a few hours. However, no damages were reported.

Flooding occurred in both the Chenderiang and Kampar rivers, which are the tributaries of Kinta River (a major tributary of the Perak River). The Chenderiang River overflowed its bank on 25 July and flooded the adjoining areas on both banks around Chenderiang town. The flood level at the main road bridge was the highest ever recorded (31.98 metres) and a total of 191 mm rainfall was recorded during a 24-hour period (35 years return period). However, no damages were reported except that a few mines around the area were flooded. At dawn on 25 July flood waters overtopped Sg. Kampar and caused breaches of the right bund upstream and downstream of the main road bridge at Kuala Dipang. Flooding to depths of 1.2 m was reported, covering an area of approximately 80 ha; about 130 people were evacuated. However, the water level in Kampar slowly subsided that afternoon. The actual amount of damages was not assessed; however, the cost of repair works to fill up the breaches and strengthen the river bund was about $M 16,000.[14]

Selangor

Localized flooding occurred in Kuala Selangor on 17 November and lasted for about a week. The depth of flooding varied between 0.2 m and 0.9 m. Flooding resulted from heavy rain and insufficient channel capacities. The total monetary losses were estimated to be $M 69,500. A flash flood occurred in mid-June in several areas in Ulu Langat. The depth of flooding varied from 0.2 m to 1 m. Another flash flood occurred in Kuala Langat district towards the end of 1979. The depth of flooding varied between 0.2 and 0.5 m.

A drought occurred in June 1979 in Tanjung Karang and Kuala Selangor. About 1,300 ha of crops such as coconuts, cocoa, rubber and oil palm were affected. Total losses due to destruction of crops and reduction in yields were estimated to be $M 14,000.

Federal Territory

Flash floods occurred on 22 occasions from January to June 1979, and three more flash floods occurred in November. The duration of flooding varied from 1 to 15 hours. The causes of flooding were heavy rainfall, insufficient channel capacities and poor infrastructural drainage systems. Depth of flooding varied from 0.2 to 2.4 m. There were no reports of drought in the State during the year.

Negeri Sembilan

There was no report on the occurrence of flood. About 45 ha of paddy were destroyed at Batang Rokan 60 of Tampin district as a result of drought.

Malacca

There was no report of either flood or drought in the State during the year.

Johor

A major flood hit part of Johor during late November and early December. The areas worst hit were the catchments of Sg. Segamat, Sg. Simpang Kiri, Sg. Macap and the lower catchment of Sg. Johor. Moderate flooding occurred in the middle catchments of Sg. Muar, Sg. Bekok, Sg. Sembrong (west) and Sg. Kahang. Localized floods were in the catchments of south-west Johor at Sg. Pontian Besar and south Johor at Sg. Scudai. There was no flooding in the north-eastern part of the State. Total flood damages sustained were valued at $M 293,200, mainly from damages to cash crops and poultry, and were centred in Segamat district. The total amount of welfare supplied to the evacuees in such forms as food, utensils and blankets amounted to $96,647. The total number of villages affected was 131 and there were altogether 10,059 evacuees. The road at milestone 83 on the Johor Bahru – Labis road was submerged to a depth of 0.9 m for about 20 hours, seriously affecting communications. There was no report on the occurrence of drought in the State during the year.

Pahang

A total of between 400 and 700 mm of catchment rainfall was recorded in the Kuantan River basin towards the end of 1979. During the same period, a total of 90 mm of catchment was recorded in the Pahang River basin. Thus, severe flooding hit the Kuantan River basin whereas the Pahang River basin was less affected. The most severely affected village in the Kuantan River basin was Kg. Sg. Lembing, where as many as 8,000 people were evacuated. No damage data are yet available.

As to the Pahang River, the flood damages in certain parts of the main and branch canals and farm roads of the Paya Ganchong Irrigation Scheme (located on the flood plain on the north bank of the Pahang River from 20 to 30 km upstream of the mouth of the river), were estimated at $M 7,200. Damages to bunds and spillway at Temerloh district were estimated at $M 12,600. Damages to livestock, paddy and other crops are not yet known.

No reports of drought were received from the State for the year.

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[14] $M 2.188 = $US 1.00 (1979 period average).

Trengganu

A severe flood hit the Trengganu River basin towards the end of November. The total catchment rainfall from 25 to 28 November was 350 mm. At the height of the flood, the water level at Kg. Tanggol (flood assessing point) was 1.34 m above danger level. Many villages were flooded and about 4,262 people were evacuated. One boy was drowned.

The losses in monetary terms were $M 561,525. The breakdown of the losses are: (a) livestock, $M 16,548 (2.9 per cent of total losses due to flood); (b) agricultural facilities, $M 175,031 (31.2 per cent); (c) houses, $M 8,000 (1.4 per cent); (d) paddy, $M 308,757 (55 per cent); (e) other crops, $M 53,189 (9.5 per cent).

Drought destroyed paddy worth $M 33,600 and other crops worth $M 55,041, which make up total losses in monetary terms of $M 88,641.

Kelantan

Between 2,525 and 2,685 mm of rain was recorded in the State for 1979. The maximum 24-hour rain of 384 mm was recorded in Lubok Bongor on 26 November. From 23 to 27 November, about 250 mm of catchment rainfall fell in the upper catchment of the Kelantan River, which caused a major flood in the State. This flood was the second largest flood since 1967. The total number of evacuees was 30,855; 445 houses were damaged and eight others washed away. Nine people were killed in the flood. Total monetary losses in agriculture, infrastructure and government properties were estimated to be $M 1.3 million. Sixty per cent of total monetary losses were from agricultural losses. No major drought was reported for 1979 and agricultural losses from drought were negligible.

2. Sabah

In general, 1979 was uneventful in respect of flood or drought. However, exceptional rain fell along the west coast of Sabah in the month of October, totalling 617.0 mm. The heaviest rainfall was on 7 October, registering 120 mm. The rainstorm in October was believed to have been caused by a typhoon in the South China Sea off the Philippines. Wind velocity recorded on 16 October was 47 knots.

As a result of these storms, a number of houses and property items were damaged or destroyed (estimated at $M 1 million) in and around Kota Kinabalu. It was also reported that there were several road slips and landslides causing interruption to traffic. However, no serious flooding occurred in the west coast region or elsewhere.

It was particularly dry in the Kudat area in the months of February, March, April and May, when the rainfall was only 58 mm, 34 mm, 33mm and 21 mm respectively. Less than 50 mm of rain in January and February were recorded in Beaufort (lower west coast region), Kinabalu National Park (Crocker Range) and Tawau (east coast). However, no data on damages due to drought were reported.

3. Sarawak

The first flood of a localized nature hit Sg. Sarawak at Kuching town and its surrounding low-lying areas on 26 January. The depth of flooding was about 0.3 m to 1.2 m above road level and was of 6 to 8 hours duration. Heavy rain and high spring tides caused the flooding.

A bigger flood occurred on 20 June in Miri town owing to heavy rainfall on 19 June (138.1 mm). The depth of flooding varied from 1.5 to 5 m above ground level. The number of evacuees totalled 538. Over 405 ha of cultivated land were affected. All shops were closed and timber camps stopped operations as water overflowed the Batang Baram.

Owing to scarce rainfall in the river catchment of Batang Limbang in the fifth division in January, drought-hit areas included Limbang, Kampung Palas, Kampung Tanjung, Lempasung, Kampung Sibukang and Jalan Pandaruan for about 20 days. About 2,000 people were affected and approximately 75,000 litres of water were supplied by the Public Works Department to the affected areas.

Because of scarce rainfall from 31 July to 16 August, the Batang Sadong and Batang Samarahan rivers were affected. Towns affected were Serian, Tarat, Baki Bazaar and Panchor. The Government Secondary School was temporarily closed. Over 2,000 pupils were affected. About 100 shophouses and a few hundred houses suffered from acute shortage of pipe water.

I. NEW ZEALAND[15]

1. Significant meteorological events in New Zealand in 1979

Some areas recorded 20 to 30 per cent more rain than usual, making 1979 the wettest year overall since 1968. Isolated storms throughout the year caused flooding in some districts of both the North and the South Islands.

At Auckland on 8 October a combination of high tides and winds gusting to 90 km/h caused the closure of roads in the waterfront area. Yachts were damaged when they broke their moorings and were driven ashore by strong winds.

On 2 December heavy rain fell in many western and southern districts of the South Island. At Mount

[15] *Source:* New Zealand Meteorological Service, Ministry of Transport.

Cook 537 mm were recorded in 24 hours, this being the highest one-day fall recorded in any month at this station since October 1942 (559 mm). A more detailed report of this event compiled by the Water and Soil Division of the Ministry of Work and Development follows.

2. Otago/Canterbury floods of December 1979

The Haast River in South Westland recorded extremely high flows in December, but the peak was not recorded because the recorder was covered by water. The damage in this area was considerable and has been estimated at $NZ 1,000,000[16] to bridges and roads on the Haast Pass Road. The inland North Otago and Canterbury rivers also recorded high flows as a consequence of the storm. In the headwaters of the Waitaki system, the Jollie River peaked on 2 December at 1930 hours at 160 m^3/sec, which has a return period of 50 years. Also, the Ahuriri River recorded a peak discharge of 550 m^3/sec at 0100 on 3 December and this flow had a return period of 100 years.

The Mount Cook (Hermitage) daily rain gauge recorded respective 0900 totals of 87 mm and 537 mm on 2 and 3 December. Damage to roads in the Mount Cook area was considerable as a consequence of these flows and rainfall totals. Inflows into the three Waitaki system lakes (Pukaki, Tekapo and Ohau) have been calculated to have a return period of 15 years or more. The Rakaia system similarly recorded a high peak discharge of 4,250 m^3/sec, which has a return period of 50 years. The Waimakariri system was high and dirty, recording a peak flow of 2,850 m^3/sec, which has a return period of 40 years.

In summary, this storm was concentrated along a narrow belt of the Southern Alps, extending from Western Southland to Canterbury. It seemed to be more intense in some areas, e.g., Mount Cook and Haast, causing considerable damage to communications.

3. Tropical cyclones in the south-west Pacific east of 160°E during 1979

There were six tropical cyclones in 1979, of which the following were destructive:

(a) In January, Hurricane Gordon passed over or close to Banks Islands, but there are no details of any damage;

(b) In February Major Hurricane Kerry caused some damage in Solomon Islands, but no details are available;

(c) In March Major Hurricane Meli caused devastation and loss of life in central Lau and Kandavu (Fiji);

(d) In December the centre of Ofa, which was a small storm, passed directly over Niue, destroying cash and subsistance crops and causing severe damage to harbour installations and buildings.

J. PAKISTAN[17]

During the year 1979 a mild incursion of the monsoon took place towards the last week of June, but was only short-lived. After a considerable break, it again advanced during the second week of July. The retreat of the monsoon started towards the last week of August and was completed by the early part of September.

Although there was almost continuous rainfall activity from the second week of July to the third week of August, the intensity of rainfall was generally moderate and there were only a few heavy spells. Moreover, the heavy falls were restricted to certain parts of the North West Frontier Province (NWFP) and northern and central Punjab. As a consequence, only one high flood peak was recorded over Chenab at Marala on 2 August.

Out of eight monsoon lows or depressions that originated from the Bay of Bengal, only four affected Pakistan (figure 21). All of these generally maintained a westward track and filled up after reaching south Rajasthan or lower Sind. A detailed description of these appears in section 2.

1. Seasonal rainfall and floods

In the seasonal isohyetal map (figure 22), the cell of maximum rainfall of 20-25 inches (500-650 mm) lies over the foothills of the Chenab and Jhelum river catchments and another cell of 10-20 inches (250-500 mm) lies over the Kohat River and the Swat Valley. The rainfall decreases to 2 inches (50 mm) or less in the southern parts of Punjab and the upper valley of the River Indus.

The isopercental map (figure 23), departure from seasonal normal, shows that over major parts of the upper catchment of the River Indus, extending from Chilas to Chashma in NWFP, the rainfall was 50-150 per cent above normal, but was practically normal in parts of Rawalpindi, Sargodha and Lahore divisions. It was 50-70 per cent below normal in south-west Punjab and slightly below normal in parts of Kashmir a d adjoining areas, the uppermost Indus Valley, Gilgit Agency and Malakand Division.

With the exception of one high flood peak at Marala on 2 August, no significant floods occurred during the season. Low and frequent medium floods

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16 $NZ 0.978 = $US 1.00 (1979 period average).

17 *Source:* Pakistan Meteorological Department, Government of Pakistan.

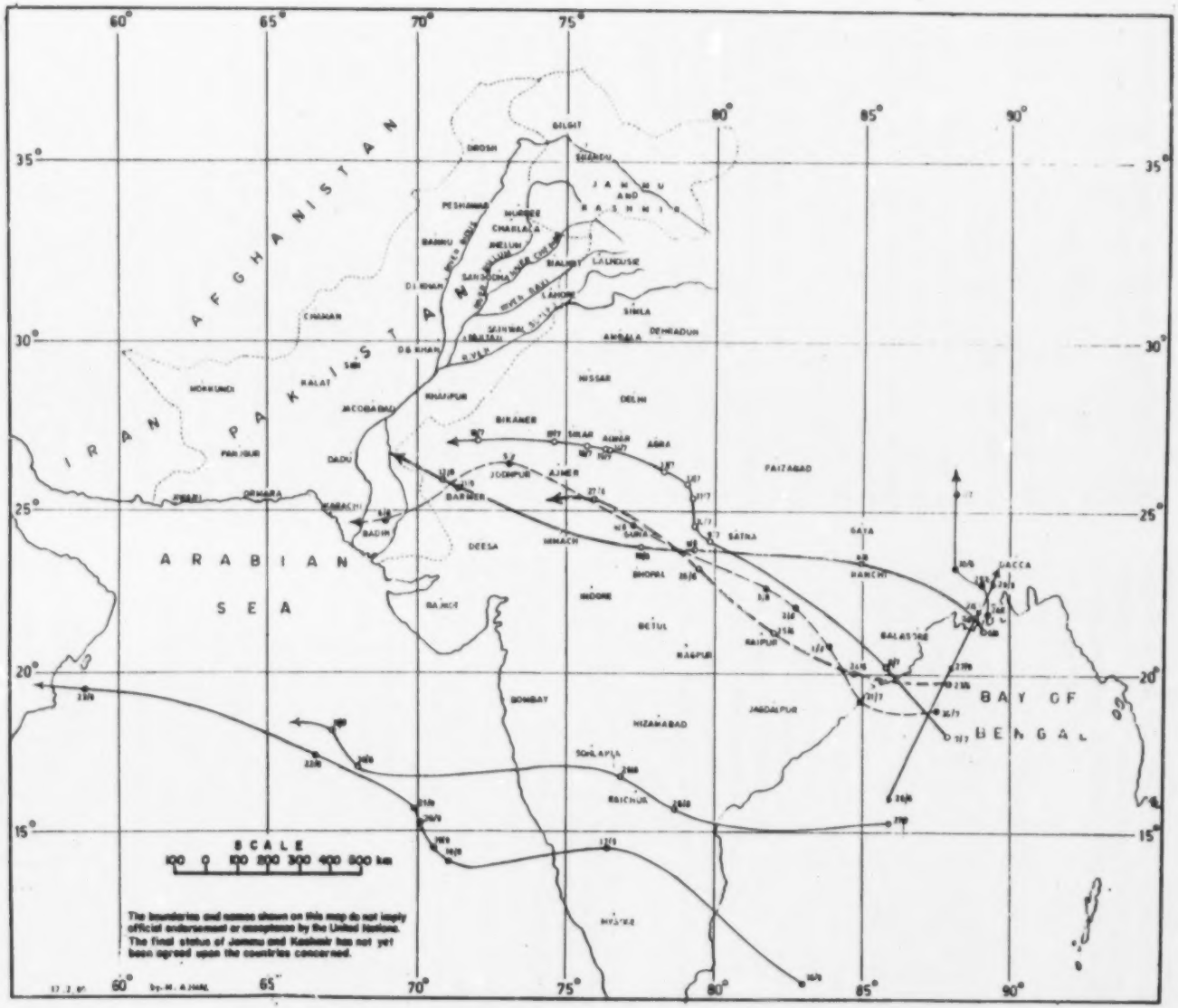
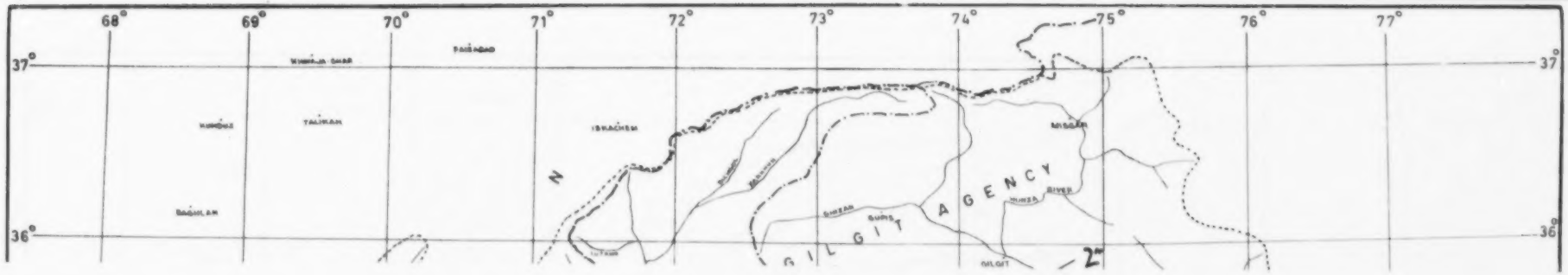


Figure 21. Tracks of monsoon depressions during the monsoon season, 1979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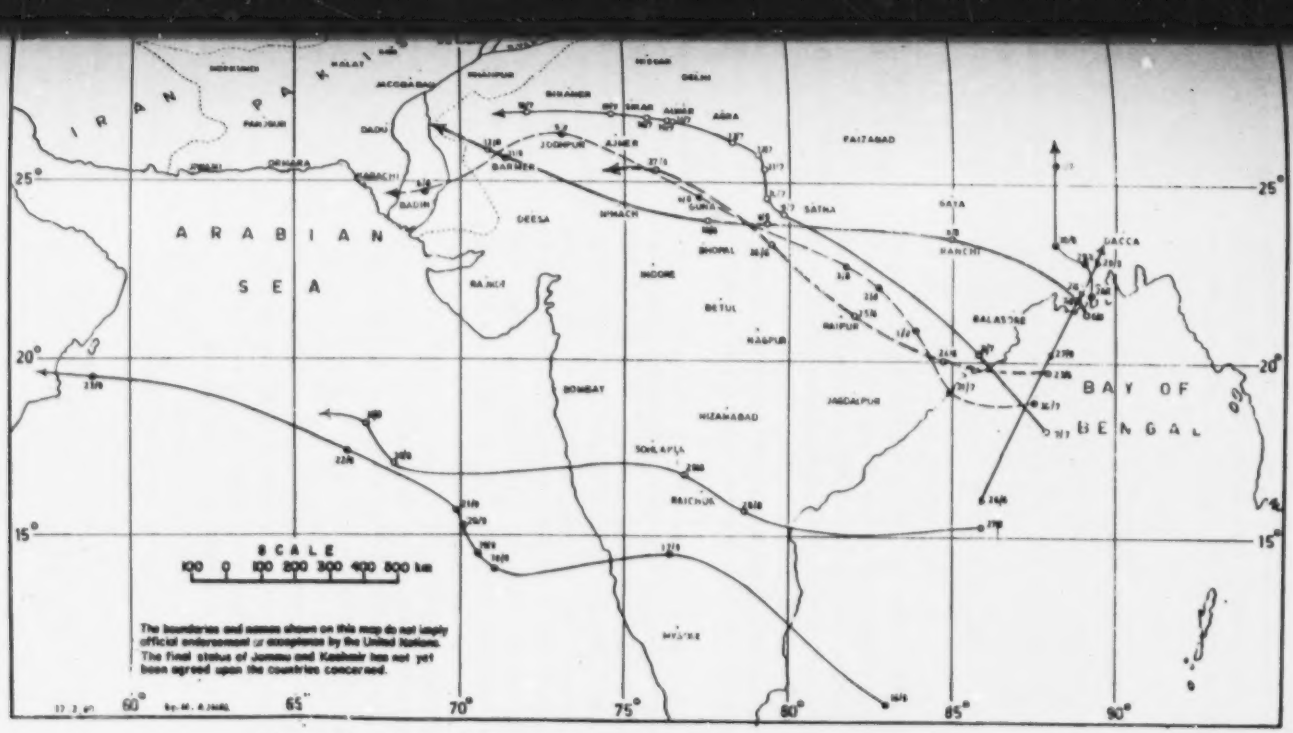
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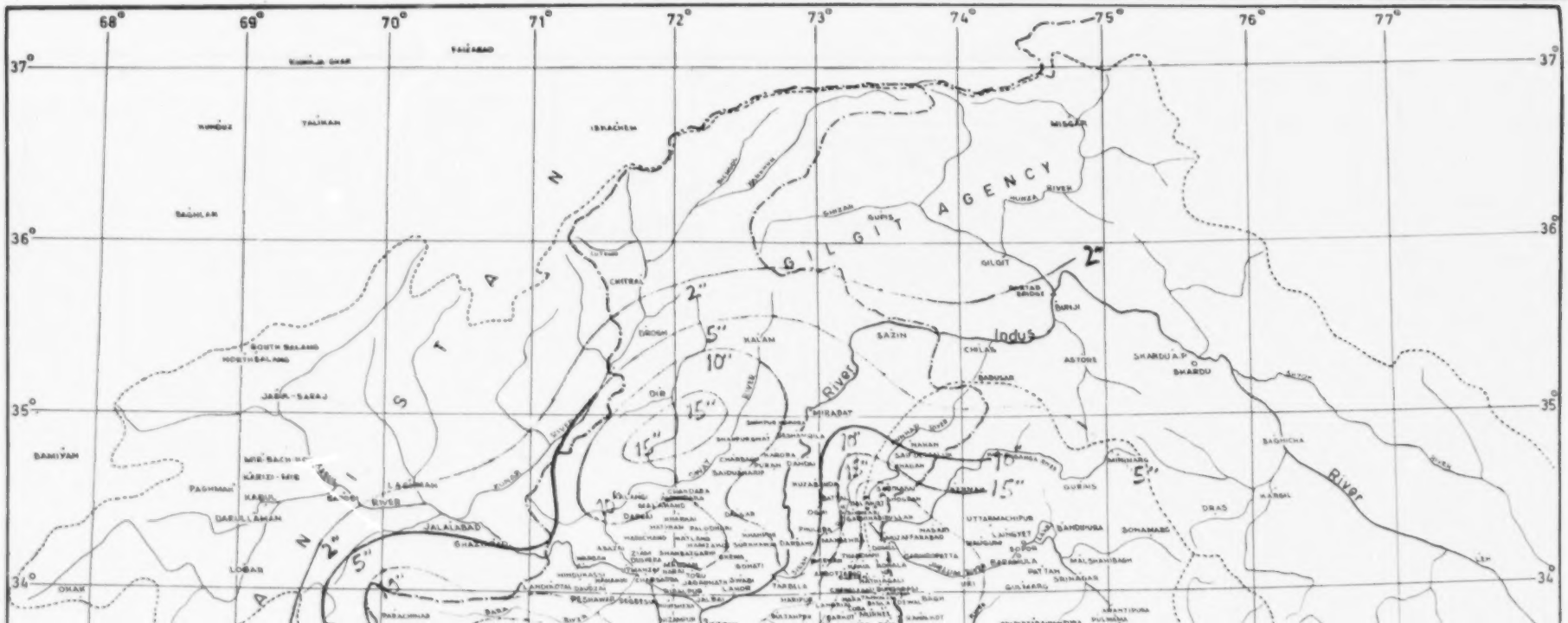
The final status of Jammu and Kashmir has not yet been agreed upon the countries concerned.

Figure 21. Tracks of monsoon depressions during the monsoon season, 1979



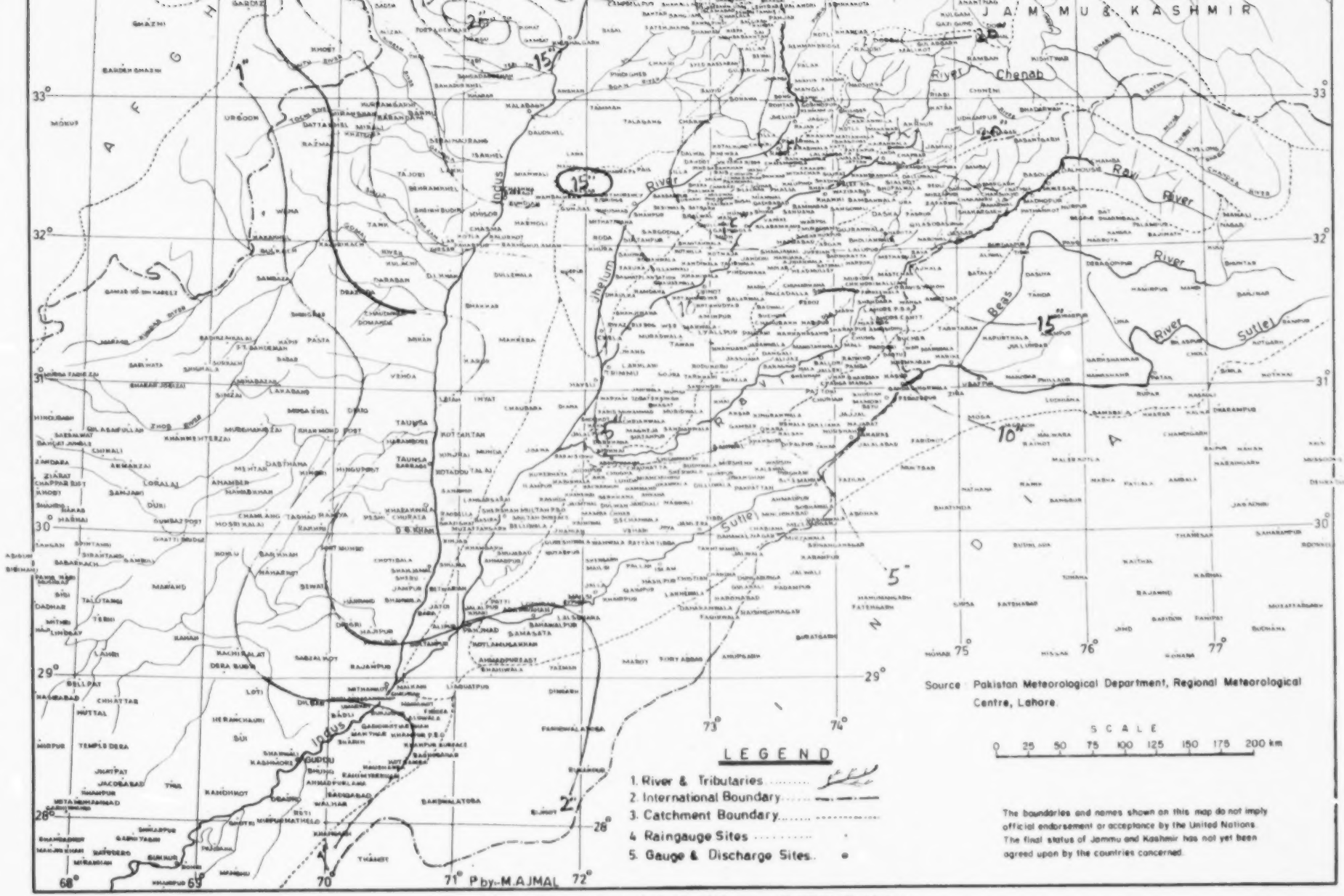
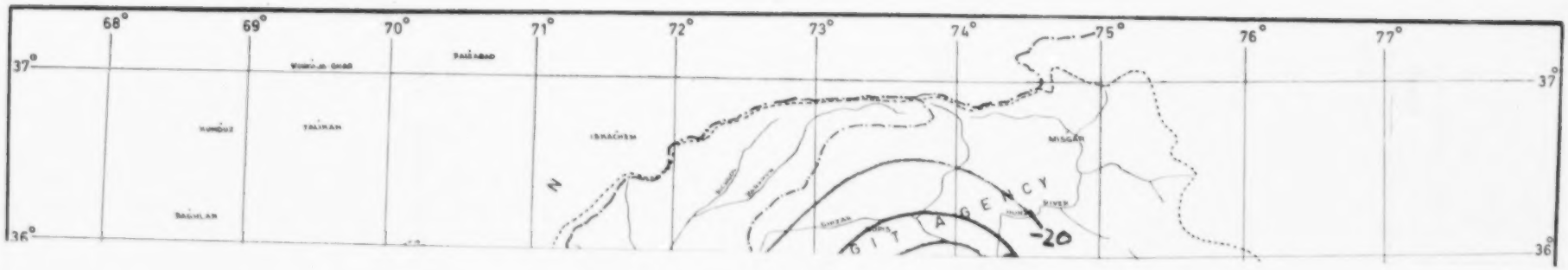

J A M M U & K A S H M I R
Chenab River
Ravi River
Beas River
Sutlej River
Indus River
Jhelum River
Source Pakistan Meteorological Department, Regional Meteorological Centre, Lahore.
SCALE
0 25 50 75 100 125 150 175 200 km
LEGEND
1. River & Tributaries
2. International Boundary
3. Catchment Boundary
4. Raingauge Sites
5. Gauge & Discharge Sites
The boundaries and names shown on this map do not imply official endorsement or acceptance by the United Nations. The final status of Jammu and Kashmir has not yet been agreed upon by the countries concerned.
Pby-M.AJMAL

Figure 22. Seasonal Isohyetal map of 1979, Pakistan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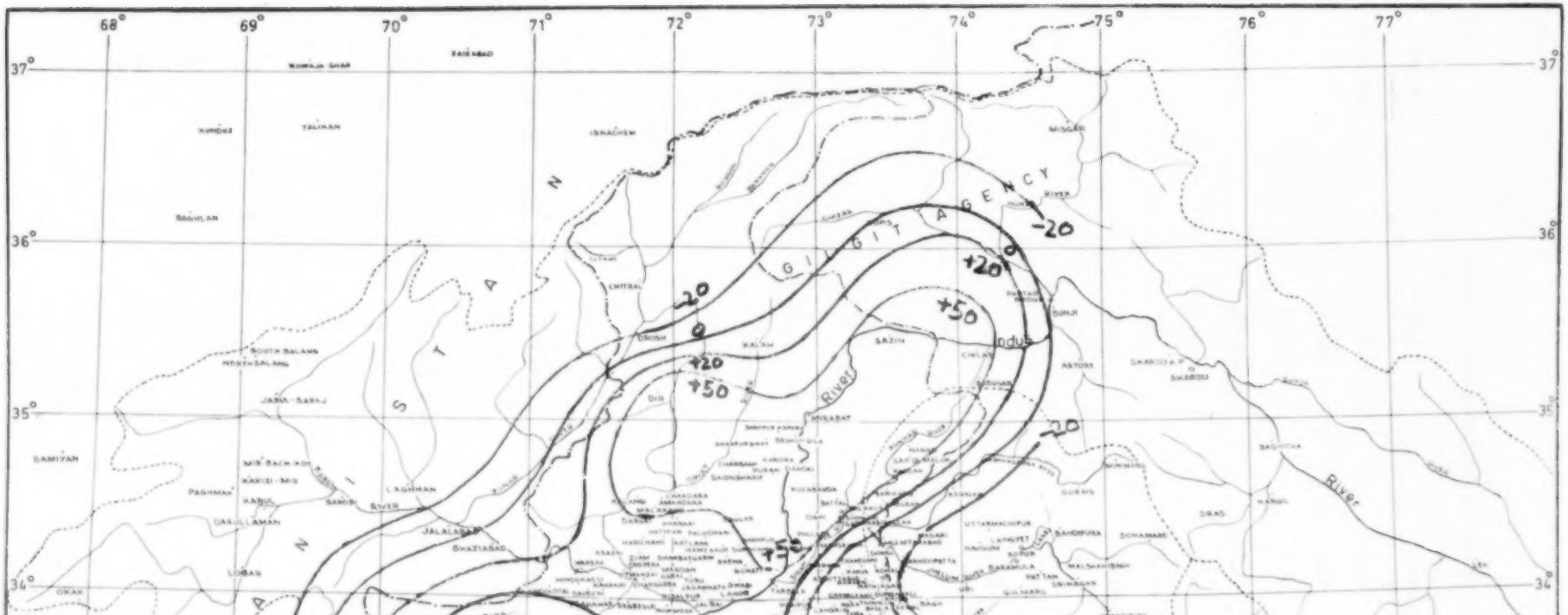
KUNDUZ
TALIKAN
IBRACHEM
MISGER
BAGHLAN
AGENCY
-20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+20
+50
GILGIT AGENCY
Indus
River
Kabul
KUNDUZ
TALUKAN
BAGHLAN
ISHKASHIM
MISGER
CHITRAL
GUPIS
SAZIN
ASTORE
SKARDU
SOUTH SALANG
NORTH SALANG
JABUL-SARAJ
SAMIYAN
MIR BACHA KOT
KABUL
LAGHMAN
JALALABAD
SHAZIABAD
LOGAR
OKAK
BANDIPURA
SONAMARG
BARAMULA
SRINAGAR
GILGIT
DRAS
KARGIL

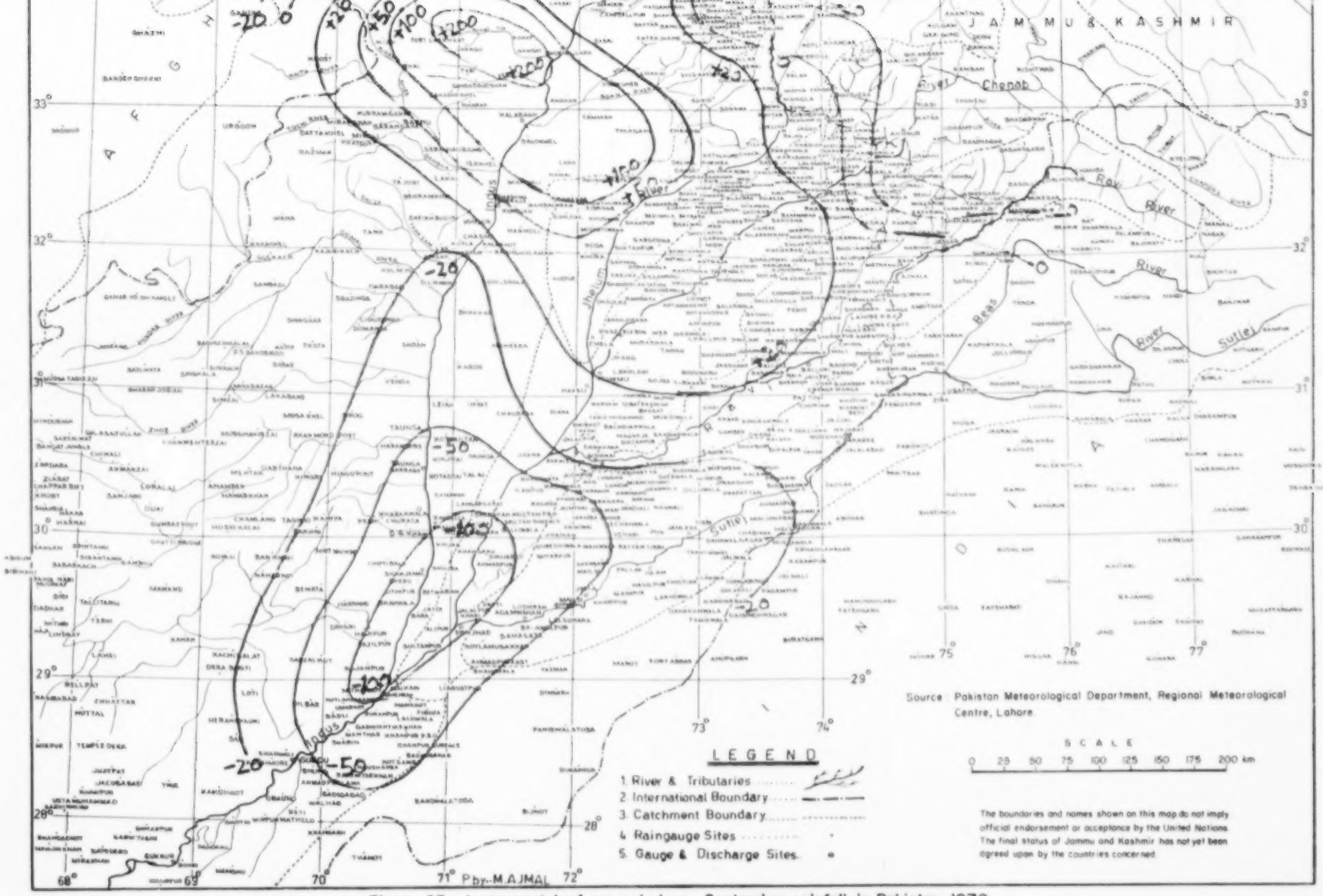
J A M M U & K A S H M I R
Chenab River
Ravi River
Beas River
Sutlej River
Jhelum River
Indus River
-20
+20
+50
+100
+200
+150
-50
-100
LEGEND
1. River & Tributaries
2. International Boundary
3. Catchment Boundary
4. Raingauge Sites
5. Gauge & Discharge Sites
Source : Pakistan Meteorological Department, Regional Meteorological Centre, Lahore
SCALE
0 25 50 75 100 125 150 175 200 km
The boundaries and names shown on this map do not imply official endorsement or acceptance by the United Nations. The final status of Jammu and Kashmir has not yet been agreed upon by the countries concerned.
Pby-MAJMAL

Figure 23. Isopercental of normal June - September rainfall in Pakistan, 1979

Table 11. R[illegible]fall spells and rivers affected in Pakistan, 1979

Period	*River*	*Flood level*	*Remarks*
24-27 June	Chenab	Low	Marala, 24 June
	Jhelum	Low	Mangla, 24 June
	Indus	Low	Kalabagh, 28 June
8-18 July	Chenab	Low	Marala, 11 July
	Indus	Low	Attock, 10-12 July
	Ravi	Below low	Jassar, 11-12 July
	Chenab	Medium	Marala, 13 and 17 July
	Chenab	Low	Marala, 18 July
	Jhelum	Low	Mangla, 13-14 July
	Indus	Low	Attock, 12 and 15 July
20-28 July	Ravi	Low	Balloki, 23 July
	Jhelum	Low	Mangla, 20 July
	Indus	Low	Remained in low flood from 20 to 31 July
1-4 August	Ravi	Low	Jassar, 2 August
	Chenab	High	Marala, 2 August
	Chenab	Medium	Marala, 4 August
	Jhelum	Low	Mangla, 4 August
	Indus	Medium	Attock, 5 August, remained in low flood up to 9 August
18-20 August	Chenab	Low	Marala, 20 August
	Indus	Low	Remained in low flood from 11 to 24 August

Source: Pakistan Meteorological Department, Government of Pakistan.

were observed in the rivers of the Indus basin during the months of July and August only (table 11). No loss of life or property was reported.

2. Meteorological aspects of the floods

(a) *June 1979*

The first depression of the season developed on 23 June in the northern Bay of Bengal and crossed the coast on 24 June. It moved to the north-west and dissipated in east Rajasthan on 27 June. Under its influence and that of the accentuated seasonal low, a mild incursion of the monsoon current took place. It affected the eastern rivers of the Indus basin and the submontane districts of the region. Rainfalls of the order of 0.25-1.00 inch (6 to 23 mm) were recorded over these areas during the period 24 to 27 June. The rivers Indus, Chenab and Jhelum attained only a low flood level from 24 to 28 June.

(b) *July 1979*

A monsoon low developed in the northern Bay of Bengal on 7 July and crossed the Orissa coast on 8 July. After moving to the north-west, it was centred near Nowagong, in Madhya Pradesh, on 9 July. It continued to move slowly in the same direction and reached Rajasthan on 17 July, where it filled up. Under its influence and the simultaneous accentuation of a seasonal low associated with the passage of westerly waves, the monsoon advanced up to the Punjab and adjoining areas and remained fairly active during the period from 8 to 18 July. Frequent falls of 1.5 to 2.0 inches (38-50 mm) and sporadic falls of 4-5 inches (100-125 mm) were recorded in the plains of the Punjab, NWFP and parts of the catchment areas of the Indus basin. Low flood levels of the rivers Indus, Jhelum and Ravi were attained at Attock, Mangla and Jassar respectively, and medium floods of the River Chenab at Marala. Mild monsoon activity continued thereafter as a result of the accentuation of the seasonal low, which was affected by the movement of westerly waves across the north of Pakistan. A few sporadic heavy falls were also reported during this period. The principal amounts were 110 mm at Jhelum on 24 July and 79 mm at Sargodha on 25 July. These falls resulted mainly in low floods in the rivers Indus, Jhelum and Ravi.

(c) *August 1979*

Monsoon activity was prominent during the first fortnight of August. A monsoon depression, which had formed over the head of the Bay of Bengal on 30 July and crossed the coast on 31 July, initially took a north-westerly course until it reached Orissa on 3 August. Thereafter, it moved WNW across Madhya Pradesh and was centred near Jodhpur on 5 August. Subsequently, it moved in a south-westerly direction and started affecting lower Sind and finally dissipated there by 6 August. Simultaneously, a western disturbance moved across the northern areas of the region. Fairly widespread rainfall of the order of 37-50 mm occurred over the region on most of the days during the first week. However, Kotli received 94 mm of rain on 2 August and Murree 115 mm on 4 August. These rains were responsible for the only high flood peak observed at Marala on 2 August. Low to medium floods were also recorded in the rivers Ravi, Jhelum and Indus during this period.

By the time the first depression dissipated over lower Sind, the second depression developed over the head Bay on 6 August. Having crossed the coast, it moved in a north-westerly direction until 10 August and continued to move to the WNW until 12 August. It finally weakened, however, over Rajasthan and merged with the seasonal low. This depression did not hit the region directly, but under its influence a mild incursion of the monsoon continued and caused moderate-intensity rainfall of 25-50 mm over both the plains and parts of the hilly catchments of the eastern rivers. Some notable amounts recorded were 90 mm in Bahawalpur and 60 mm at Bahawalnagar on 11 August.

During the last two weeks of the month, monsoon activity gradually declined. However, occasional accentuation of the seasonal low, coupled with the passage of westerly waves, were responsible for scattered local falls of the order of 12-50 mm over the northern parts of the country. On 20 August, Jhelum received about 70 mm of rain and Sargodha and Kohat 107 mm each. The last week of the month was almost dry. Only a few falls of rain occurred over Kashmir and the northern parts of NWFP on 28 and 29 August.

(d) *September 1979*

The withdrawal of the monsoon from the country was nearly complete in the beginning of Septeber. However, under the influence of an accentuated seasonal low and the passage of westerly waves across the northern areas, scattered to local falls of moderate intensity occurred over the plains and northern parts of the country between 12 and 19 August. The significant rainfalls were 56 mm at Murre, 36 mm at Lahore, and 24 mm at Sialkot on 19 August. None of the rivers attained flood level during September.

K. PHILIPPINES[18]

Details of damage resulting from tropical cyclones and floods are shown in table 12. The damages stated in the account were primarily caused by tropical cyclones, as flood damages were generally a result of tropical cyclones and were therefore consolidated with the latter.

[18] *Source:* Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), Ministry of National Defense, Philippines.

Table 12. Tropical cyclone damage in the Philippines, 1979

Cyclone	Type[a]	Name	Period of occurrence	Damages to property, public and private (1,000 pesos)[b]	Casualties		
					Dead	Injured	Missing
01	TY	Auring	22-23 March	–			
02	TY	Bebeng	12-20 April	267,188	30	73	63
03	TS	Karing	10-16 May	–			
04	TD	Diding	23-24 May	–			
05	TY	Etang	30 June-05 July	118			
06	TS	Gening	05-09 July	–			
07	TS	Herming	25-29 July	2,500			
08	TY	Ising	29 July-02 August	3,980			
09	TD	Luding	03-06 August	–			
10	TY	Mameng	09-15 August	45,234	24		3
11	TY	Neneng	19-23 August	–			
12	TS	Oniang	01-02 September	–			
13	TY	Pepang	16-19 September	72,298	8		2
14	TY	Rosing	23-27 September	–			
15	TD	Sisang	01-04 October	285			
16	TS	Trining	03-05 October	–			
17	TY	Uring	05-11 October	18,640	1		
18	TY	Warling	13-16 October	–			
19	TY	Yayang	04-07 November	4,574	6		
20	TS	Ading	08-11 November	–			
21	TY	Barang	09-13 December	–			
22	TS	Krising	21-24 December	–			
			Total	414,818	69	73	68

Source: National Disaster Co-ordinating Council, Ministry of National Defense, Philippines.

a TD = tropical depression; TS = tropical storm; TY = typhoon.

b Pesos 7.387 = $US 1.00 (1979 period average).

Table 13. Damage from natural disasters in the Republic of Korea, 1979

Type of damage	*Storm (29 Jan.-2 Feb.)*	*Heavy rain (24-26 Jan.)*	*Heavy rain (1-5 Aug.)*	*Typhoon Irving (16-17 Aug.)*	*Typhoon Judy (25-26 Aug.)*	*Hail Storm (2-11 Oct.)*	*Others*	*Total*
PRIVATE SECTOR								
Casualties - total (persons)	25	46	178	40	208	13	26	536
Dead/missing	19	40	140	17	136	12	26	390
Injured	6	6	38	23	72	1	–	146
Submerged area - total (ha)	483	47,212	36,745	1,217	52,404	–	25	138,086
Dry field	22	2,568	10,930	49	1,333	–	8	14,909
Rice paddy	129	44,644	25,815	1,167	49,643	–	17	121,415
Others	332	–	–	2	1,428	–	–	1,762
Cultivated land - total (ha)	0	2,416	2,048	12	3,232	6	–	7,715
Dry field	–	179	1,150	1	338	5	–	1,674
Rice paddy	–	2,237	898	11	2,894	1	–	6,041
Value (millions of won)	–	2,316	3,285	63	4,625	19	–	10,308
Crops lost (tons)	–	37,199	62,972	98,371	8,984	12,483	19	220,028
Value (millions of won)	63	12,343	20,475	38,350	1,417	2,711	9	75,368
Buildings - total	136	778	2,607	1,381	11,742	64	323	17,031
Destroyed	9	203	1,082	466	1,078	19	10	2,867
Damaged	48	183	1,138	683	2,290	5	129	5,176
Submerged	79	392	387	232	7,674	40	184	8,988
Cost (millions of won)	35	213	2,977	437	1,930	32	15	5,639
Vessels								
Ships and sailboats - total (number/tonnage)	269/718	31/57	63/43	419/51,041	110/212	1/2	83/1,003	976/53,078
Completely damaged (tonnage)	434	43	32	9,839	122	2	860	11,332
Half damaged (tonnage)	284	14	11	41,202	90	–	143	41,746
Cost (millions of won)	297	19	15	6,384	68	1	270	7,054
Subtotal (millions of won)	395	14,891	26,752	45,234	8,040	2,763	294	98,369
PUBLIC SECTOR								
Roads and bridges (sites)	50	337	497	158	890	11	17	1,960
Cost (millions of won)	59	515	1,990	280	3,262	40	15	6,161
River embankments (sites)	1	677	571	79	872	1	5	2,206
Cost (millions of won)	–	3,399	4,820	300	9,565	64	3	18,151

Type of damage	*Storm (29 Jan.-2 Feb.)*	*Heavy rain (24-26 Jan.)*	*Heavy rain (1-5 Aug.)*	*Typhoon Irving (16-17 Aug.)*	*Typhoon Judy (25-26 Aug.)*	*Hail Storm (2-11 Oct.)*	*Others*	*Total*
Waterworks (sites)	–	14	10	–	151	1	–	176
Cost (millions of won)	–	33	43	–	600	1	–	677
Harbour facilities (sites)	27	–	–	215	28	2	3	275
Cost (millions of won)	233	–	–	2,785	101	188	11	3,318
Schools								
Rooms	1	4	43	76	91	2	6	223
Buildings	1	7	–	4	83	1	6	102
Cost (millions of won)	1	9	172	42	359	–	3	586
Railways (sites)	–	1	8	–	15	–	–	24
Cost (millions of won)	–	6	10	–	93	–	–	109
Irrigation facilities (sites)	–	452	506	60	1,153	–	–	2,171
Sea dikes (sites)	96	4	1	–	40	–	24	165
Cost (millions of won)	102	1,857	2,634	199	6,602	–	210	11,604
Erosion control (sites)	–	30	231	5	162	2	1	431
Cost (millions of won)	–	19	457	11	936	6	–	1,429
Plantings (sites)	–	11	73	1	33	–	2	120
Cost (millions of won)	–	57	78	29	230	–	–	394
Telecommunications (poles)	78	4	235	179	1,197	–	–	1,693
Cost (millions of won)	4	3	22	15	89	–	–	133
Military facilities (sites)	4	–	1	38	1	–	13	57
Cost (millions of won)	58	–	456	40	2,229	–	6	2,789
Saemaul facilities (sites)	54	1,525	1,704	102	3,123	20	–	6,528
Cost (millions of won)	42	1,958	5,351	693	9,387	53	–	17,484
Other costs (millions of won)	1,579	239	1,610	3,516	11,811	7	591	19,353
Subtotal (millions of won)	2,078	8,095	17,643	7,910	45,264	359	839	82,188
Total (millions of won)	2,473	22,986	44,395	53,144	53,304	3,122	1,133	180,557

Source: Central Meteorological Office, Republic of Korea.
Note: 484 won = $US 1.00 (1979 period average).

L. REPUBLIC OF KOREA[19]

Details of damage from natural disasters in the Republic of Korea during 1979 are shown in table 13.

M. SINGAPORE[20]

No tropical cyclones affected Singapore during the year 1979. However, short duration local floods were experienced several times during the year. No lives were lost and damage to property was not serious. One spell of 15-day drought was experienced in January, but no damage or severe loss of property was attributed to this event.

N. SRI LANKA[21]

There were no significant tropical cyclones or floods affecting Sri Lanka in 1979. A deficit in rainfall during the first four months of the year, however, affected power generation and water supply.

For the second year in succession, warmer and drier weather prevailed over Sri Lanka January to March. Intermonsoonal thundershowers developed during the second half of April but were scattered and confined to the south-west of the island.

The deficit in rainfall up until the end of April threatened a severe water and power supply cut, since 85 per cent of the electricity is generated by hydropower and is dependent on adequate rainfall in the catchment areas. Fortunately, a severe cyclonic storm in the Bay of Bengal brought widespread heavy rain from 8 to 11 May and the crisis arising from water shortage was averted.

The south-west monsoon set in on 12 June, three weeks later than normal, and rainfall was well below normal until the end of August. September, on the other hand, was an exceptionally wet month, one of the wettest on record. October and November were also much wetter than average, as a result of widespread intermonsoonal thundershowers. A moist north-east monsoon gave widespread rain in December.

O. THAILAND[22]

1. General summary

The most significant weather event in Thailand during 1979 was the occurrence of drought during the rainy season, which damaged farmland of about 420,000 ha in upper Thailand.

From January to February the cool weather, particularly in the northern and north-eastern regions, was normal for the season. The temperature gradually increased towards the end of the season. The hot season began in early March and ended in mid-May. A low heat cell dominated upper Thailand (including the northern, north-eastern, central and eastern regions during most of the season with a southerly wind prevailing over the country. The temperature was not too high, because of occasional rainfalls. The extreme maximum temperature over the country was 42.7°C at Nakhon Ratchasima in the north-east in April, while 40.0°C was the record high for Bangkok since 1951.

A low-pressure trough moved northward from the extreme south of the country during the middle of May. Consequently, the south-west monsoon with scattered showers began to affect the country, bringing the beginning of the rainy season. The monsoon occasionally strengthened owing to the influence of tropical depressions that came close to or passed over the country.

The first depression, originating in the South China Sea, moved towards the coast of Viet Nam and passed over the extreme north of the north-eastern region during 9-10 August, dissipating over the western border of the north-east. The second depression, downgraded from Tropical Storm Nancy after it landed on the coast of Viet Nam, moved through the lower portion of the north-east and the upper portion of the central region from 24 to 25 September. It eventually dissipated over the border of Burma. Copious rainfall caused by depressions, and occasional strong south-west monsoons, resulted in isolated floods in upper Thailand and the upper portion of the southern region during the rainy season.

During the middle of the rainy season, in July and August, droughts occurred, damaging farmland in the northern, north-eastern, central and eastern regions (see table 14).

The cool season (October-January) began about the middle of October. Early in the season, a low-pressure trough lay across the head of the Gulf of Thailand and then moved southward rapidly. Meanwhile, the north-east monsoon prevailed over Thailand, bringing cool weather to upper Thailand and to the upper portion of the south. The extreme minimum temperature over the country was 7.3°C at Chiang Rai at the end of December.

Damage caused by floods and strong monsoons throughout the year in Thailand was valued at about 53 million baht[23] with the loss of 43 lives, while most of the damage caused by droughts could not be evaluated.

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[19] *Source:* Central Meteorological Office, Republic of Korea.

[20] *Source:* Meteorological Service, Singapore.

[21] *Source:* Department of Meteorology, Sri Lanka.

[22] *Source:* Meteorological Department of Thailand.

[23] Baht 20.419 = $US 1.00 (1979 period average).

Table 14. Damage caused by floods and droughts in Thailand, 1979

Region	Damage to individuals affected								Damage to public facilities							Total estimated damage (1,000 baht)
	Human lives (number)		Houses		Livestock (head)	Farmland affected (ha)		Estimated damage[a] (1,000 baht)[b]	Schools	Government offices	Weirs	Temples	Drainage	Highways and bridges	Estimated damage (1,000 baht)	
	Injured	Lost	Destroyed	Partly damaged		Flood	Drought									
North	4	4	20	421	4	4,997	201,820	317	–	–	13	–	–	58	4,613	4,930
North-east	–	6	160	1,885	...	44,566	135,372	278	3	1	56	2	624	193	28,490	28, 768
Central plain	–	1	51	105	–	107	41,738	941	1	–	–	1	–	105	6,404	7,345
East	–	–	2	...	350	296	41,491	...	–	...	–	–	–	–	...	...
South	2	31	127	943	–	7,735	...	2,893	–	...	1	–	1	107	8,157	11,050
Whole country	6	42	360	3,354	354	60,351	420,421	4,429	4	1	70	3	625	463	47,664	52,093

Source: Meteorological Department of Thailand.

a Estimated cost of damage to farmland caused by droughts was not available at the time of preparation of this report.

b Baht 20.419 = $US 1.00 (1979 period average).

2. Floods

Most of the floods that occurred in upper Thailand were caused by depressions, while the floods in the upper portion of southern Thailand were caused by the strong south-west monsoon. The area of farmland damaged by floods in the north was 4,977 ha, in the north-east 44,566 ha, in the central plain 107,296 ha and in the east and south 7,735 ha.

3. Droughts

Droughts occurred in upper Thailand during the middle of the rainy season in July and August owing to the prevalence of a weak south-west monsoon during most of that period. The annual rainfall in the north, north-east, central plain and east were 71, 87, 57 and 73 per cent of the normal rainfall. Rainfall on the east and west coasts of southern Thailand was 78 and 86 per cent of normal, respectively. Damage to farmland from drought affected 201,820 ha in the north, 135,372 ha in the north-east, 41,738 ha in the central plain and 41,491 ha in the east.

P. VIET NAM[24]

1. Typhoons

On 29 September, Tropical Storm Nancy reached the region bordering the provinces of Bình trị thiên – Nghệ tĩnh (17°N, 107°E), causing heavy rain; during the four days from 1900 on 19 September to 1900 on 23 September, the amount of rainfall exceeded 900 mm in places, causing serious flooding. On 12 October, Typhoon Sarah lashed the coastal region of the provinces of Nghĩa bình – Phú Khánh (13.5°N, 109.5°E), causing heavy rainfall of 300 to 400 mm.

2. Floods

In northern Viet Nam, the area of winter rice fields affected by floods reached 190,000 ha, of which 54,000 were a total loss.

In southern Viet Nam, the cultivable area for winter rice was reduced by 70,000 ha compared with 1978 and by 240,000 ha compared with 1977; almost 10,000 ha of food crops and industrial crops in the two provinces of Quảng nam-Đànẵng and Bình trị thiên (centre of Viet Nam) were lost.

3. Severe drought

Between 20 September and the end of December there was no rain in the northern provinces of central Viet Nam. The prolonged drought had a serious impact on agricultural production in the winter season.

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[24] *Source:* Hydrometeorological Service of Viet Nam.

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